SAN FRANCISCO
PUBLIC LIBRARY

REFERENCE
BOOK

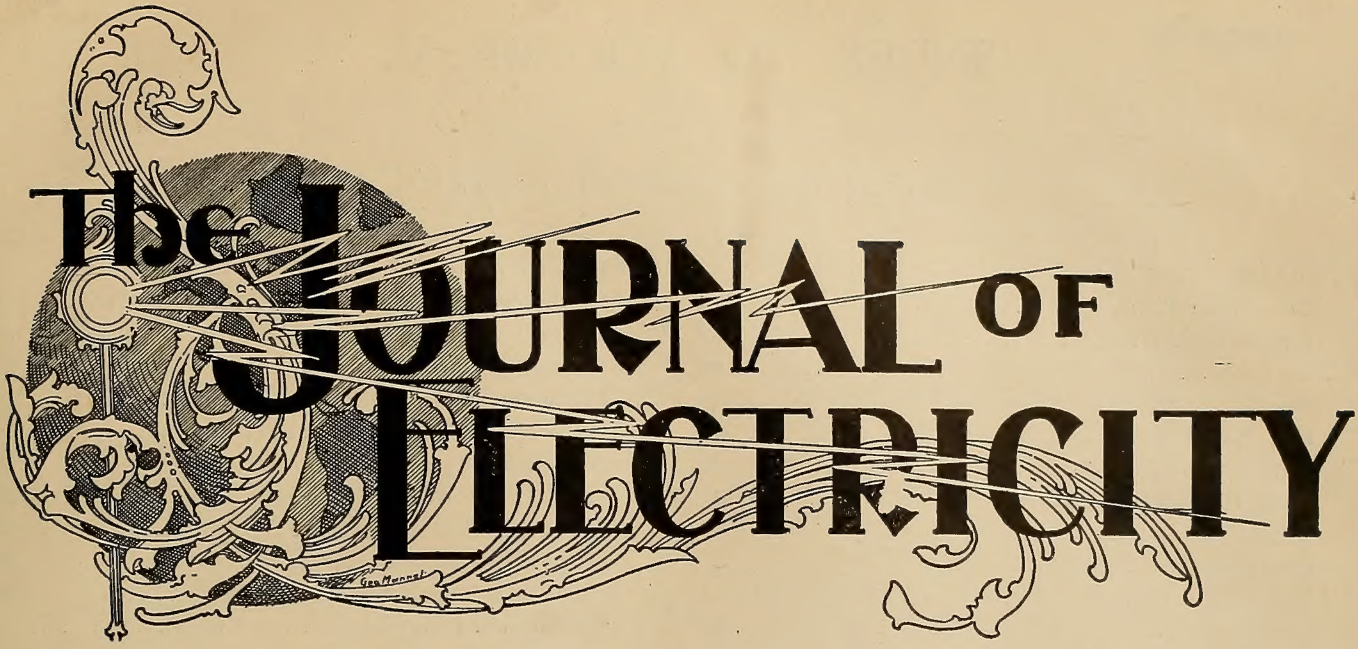
Not to be taken from the Library

Digitized by the Internet Archive
in 2011 with funding from
California State Library Califa/LSTA Grant

http://www.archive.org/details/journalof511897761899paci

O. Brooks

4 42348 SFPL:F-BKS
184SFL 11/30/98 5222



The Journal of Electricity

* * *

VOLUME V.

* * *

OCTOBER-JUNE

1897-8

* * *

SAN FRANCISCO,
Cal.

J 82
444570

INDEX TO VOLUME V.

Illustrated articles are indicated by an asterisk (*)

PAGE

Authors

Bell, Albert T. 115
Bly, Leon W. 169
De Sabla, E. J., Jr. 39
Everest, A. R. 173
Fry, Donald H. 125, 128, 163
Hutton, C. W. 37
Jones, Philip Mills, M. D. 117, 132
Knight, Samuel N. 32
Low, Geo. P. 1
Martin, Jno. 41
McGhie, J. 18
Perrine, Dr. F. A. C. 84, 98
Rix, E. A. 95
Sprout Sidney 93
Steinmitz, Charles Protens 104
Stuart-Smith, W. 29, 56
Sutcliffe, E. W. 40
Theberath, Theo. E. 34
Van der Naillen, A. 78
Wurts, Alexander Jay 77

Editorial

An Electrical Regiment 160
An Instance of Electrical Vagary 136
Are News Notes Wanted? 120
A Word of Caution 30
Concerning Electrical Charletans 101
Electricity and the Press 62
Fatalities from Low-Volt Shocks 103
Give Honor to Whom 180
He Wins the Second Prize too 135
It will be Welcomed 23
Proof Positive of a Great Circulation 121
Standard Electrical Diagrams 120
Station Switchboards 102
The Blue Lakes Plant 22
The Lining of the Rainless Clouds 135
The Salesman of the Future 182
The Tendency of Electrical Progress 80
The Truth, but not the Whole Truth 61
Transmission at 30 000 volts 44
Two Sister Sciences 60
Wheels Within Wheels 45
Where Theory Failed 22
Working Our Way Abroad 60

Educational

*Alternate Current Workings, by Donald H. Fry.
  Part I—Alternating Currents 125
  Part II—Polyphase Currents 128
  Part III—The Calculation of Polyphase Circuit Functions 163

PAGE

Electro-Economics

*A Storage Battery Wattmeter 167
Central Station Switchboards, by Dr. F. A. C. Perrine, 98
Determining Meter Rates 24
*Some Station Wrinkles 49
  Part I—How Mount Lowe is Climbed 50
  Part II—The Saving of Oil 51
  Part III—Water Rheostats 52
  Part IV—Compressed Air 53
  Part V—Miscellaneous 55
The Gain in Using Latest Transformers 86
*Transformer Regulation, by A. R. Everest. ....

Electro-Therapeuty

Accumulators in Dentistry 63
*A Large Electro-Magnet for Oculists Use, by Philip Mills Jones, M. D. 117
On the use of Electric Current from Central Stations, Philip Mills Jones, M. D. 183
Recent Uses of Electricity in Medicine, by Philip Mills Jones, M. D. 132

Fraternal

Constitution and By-laws of the Transmission Association 105
The Electric Transmission Association at Sacramento 47
The Transmission Association 88
The Transmission Association 105

Gas

Acetylene and Transmission Interests 77
A Fraud Upon Electricity, by Sidney Sprout 93
Insurance Restrictions on Acetylene 24
The Explosiveness of Acetylene 17

Historical

Reminiscences of Early English Stations 82
*The Brush Power Plant in the Chollar Shaft 71
The First Central Station 81

Hydraulics

An Electro-Hydraulic Analogue 62
Computing the Girard Governor 24
Hydraulic Problems, by W. Stuart-Smith 29
*Inertia in Governor Mechanisms 66
Water Wheel Regulation, by S. N. Knight 32

Illumination

An Invaluable Book for Lamp Users 107
An Oxidation Resisting Arc Carbon 62
*A Perfected Enclosed Arc Lamp 167
*A serviceable Lamp Guard 88
*A Successful Alternating Arc Lamp 48
Determining Meter Rates 24

INDEX TO VOLUME V.—CONTINUED.

PAGE

Edison Lamps for Isolated Plants 107
*Electricity on a Light ship 119
*Electric Power with Lighting as an Adjunct 140
*Enclosed Alternating Current Arc Lamp 67
Novelties in Incandescent Lamps 143
*Something New in the Pump Line 123
*Specialties in Incandescent Lamp Shades 108
*The New G. E. Enclosed Arc Lamp 144
The Efficiency of Illuminants 45
The Waning of the Welsbach 121

Industrial

A New Electric Supply House 88
*A New Line of Small Motors 143
Mr. J. W. Brooks Retires 167
New Agencies for the Coast 26
Organ Blowing by a Rotary Fan 88
What is "Kip?" 143

Literature

"A Pocket Dictionary of Electrical Words, Terms and Phrases," by Edwin J. Houston, Ph. D. 137
"Manual of Static Electricity in X-Ray and Therapeutic Uses," by S. H. Monnell, M. D. 138
"The American Newspaper Annual" 138
"The Treatment of Disease by Electric Currents," by S. H. Monnell, M. D. 182

Mining

*A Successful Mine Hoist 25
Electricity in Mine Haulage 68
Electricity in Mining 131
Electricity in Mining, Part II 176
*Platinum in Gold Placer Deposits 59
Sand Power for Mining Purposes 161

Miscellany

Alaska as it is 159
*A Prony Brake Experiment 74
Consolation 166
*Electricity at the Trans-Mississippi Exposition 27
Electricity on a Modern Warship 160
European and American Practices, by J. McGhie 18

Passing Comment

An Exceptionally Excellent Edition 121
A Number Without Illustrations 45
A Charge in a Contemporary 103
Coal at Five Cents a Pound 161
Pure Politics, then Public Ownership 65
Success in Advertising 45
The Engineering of the Blue Lakes Plant 46
The "Kilovolt-Ampere" 103
There's No Experiment About It 46
Wanted, A Name 137

Personal

Addison, Dr. Thos 36
Baird, M. E. 87

PAGE

Barbour, F. F. 42
Bly, Leon W. 159
Boggs, L. S. 42
Breyton, A. P. .... 42 to 87
Brooks, J. W. 26
Burkholder, W. A. 66
Cranston, J. A. 26
Crockett, J. B. 106
Cole, John R. 106
Copeland, Prof. G. A. 142
Duncan, Dr. Louis 106
Dutcher, C. E. 26
Field, Stephen D. 66
Fraley, Geo. B. 26
Fry, Donald H. 26
Fujioka, I. 142
Godfrey, J. W. 106
Goode, H. W. 42
Greenwood, Geo. D. 42
Hawley, F. W. 26
Hoffman, Theo. 141
Hunt, A. M. 106
Jones, E. C. 123, 141
Jones, Philip Mills, M. D. 123
Keith, Dr. N. S. 87
Knight, C. S. 106
Lighthipe, J. A. 42
Macdonald, T. H. 87
Marsh, L. E. 123
Morgan, Ross 47
Morton, Jr., Clifton 66
Parrine, Dr. F. A. C. 84, 98
Pemberton, L. B. 26
Ridley, A. E. Brooke 26
Shock, T. A. W. 66
Sinclair, H. H. 142
Smith, S. Morgan 42
Sprout, Sidney 42
Stockdale, James T. 159
Stuart-Smith, Lieut. W. 159
Thompson, John West 87
Van der Naillen, Prof. A. 142
Vineing, Henry E. 106
Wybro, H. C. 87
Young, C. S. 26
Zijima, Zentaro 141

Pneumatics

An Electro-Pneumatic Transmission 58
*Compressed Air at the Gwin Mine, by E. A. Rix 95
*Compressed Air in Central Stations 53

Steam

Steam in Future Central Stations 136

Telegraphy

The Infancy of the Telegraph 43
Wireless Telegraphy at the Omaha Exposition 117

INDEX TO VOLUME V.—CONTINUED.

PAGE

Transportation

A Chapter on Micanite....48
Centralizing Railway Power Stations....23
*Details of the Mount Lowe Railway....130
Flooding an Electric Conduit Road....65
*How Mount Lowe is Climbed....50
Polyphase Motors in Railway Works, by Charles Pro-
*Supplanting Steam With Electric Traction....78
teus Steinmitz....104
The Mountain Railways of Switzerland, by A. Van der Naillen....78
The New Problem in Transportation....46
The Third Rail System in a Snowstorm....159
Three-Phase Traction....65

Transmission

An Answer to Mr. Sutcliffe's Inquiries, by Alexander Jay Wurts....77
An 110-Mile California Transmission....134
*A Sierran Transmission, by Geo. P. Low.
  Part I.—The Water Supply....1
  Part II.—The Canal System....3
  Part III.—The Pipe Line....4
  Part IV.—The Power House....6
  Part V.—The Hydraulic Plant....7
  Part VI.—The Electric Plant....9
  Part VII.—The Amador Circuit....12
  Part VIII.—The Calaveras Circuit....14
  Part IX.—Financial....16
  Part X.—Personal....17
A treatise on Lightning Arresters....168
Builders of the Blue Lakes Plant....28
.*Electric Power in Large Units....122
*Gruesome Evidences of a "Hot Time" on the Old Line.69
*Imperial Porcelain Insulators....27
Insulators for Transmission Lines, by Jno. Martin....41
Lightning and Long Transmission, by E. W. Sutcliffe..40

PAGE

Lightning at Sacramento, by C. W. Hutton....37
Lightning in Nevada County, by E. J. De Sabla, Jr....39
Lightning on Transmission Lines, by Theo. E. Theberath, M. E....34
*"Locke" High Potential Insulators....107
Measuring Three Phase Currents....161
Progress of the Niagara-Buffalo Transmission....116
Properties of High Potential Insulators, by Albert T. Bell....115
Representative of its Best Practices....57
*Some Experiments at 30,000 Volts....162
*Some Transmission Practices—
  Part I.—Synchronizing Two-Phasers....70
  Part II.—An Historic Transmission....71
  Part III.—Changing Insulators on Live Wires....73
  Part IV.—A Prony Brake Experiment....74
  Part V.—A Novel Lightning Arrester....75
  Part VI.—A Multi-Glaze Insulator....76
*The Burning of High Potential Pins, by W. Stuart Smith....56
The Making of Porcelain Insulators, by F. A. C. Perrine, D. Sc....84
*The Newcastle-Sacramento Transmission....89
*The Pioneer Power Transmission....109
*The Provo-Mercur 40,000-volt Transmission, by Leon W. Bly....169
The Three-Part Insulator Patent....123
*The Yuba-Marysville Transmission....145
  Part I.—The Pole Line....146
  Part II.—At the Power House....148
  Part III.—The Electrical Equipment....149
  Part IV.—Going over the Water System....152
  Part V.—The Water System....155
  Part VI.—The Hydraulic Equipment....157
  Part VII.—Personal and Financial....157
  Part VIII.—Engineering Data....158
Three Colossal Generators....44

The Journal of Electricity

Vol. V. OCTOBER, 1897. No. 1

A SIERRAN TRANSMISSION

By Geo. P. Low.

HIGH in the rugged Sierras, up far beyond the reach of any but the most adventurous and where great fields of everlasting snow strikingly relieve the bleakness of the mountain fastness are the Blue Lakes—the brilliant gems of Alpine County that look out in sapphire from their settings of sombre distance. The rivulets that have nourished them into veritable inland seas ever continue to sustain them in pristine purity and how indispensible they are to perfect the grandeur of the scene is suggested in the above photographic engraving.

This and some of the illustrations which follow show the nature of the catchment area forming the source of the water supply of the Blue Lakes Water Company. Including, as it does, the entire Western Slope of the Sierra Nevadas embraced in Alpine, Amador and Calaveras Counties, in California, and being of granitic formation, sparsely wooded and limited in soil and vegetation, and not only beyond the possibility of agricultural and manufacturing operation but also far above the mineral belt so as to preclude possibility of contamination from mining, it must forever furnish a pure and abundant supply of water. The snow varies in depth from five to twenty feet and in some portions of the watershed it never disappears, while the catchment area abounds in copious springs and streams that are never failing.

Of such are the headwaters of the stream whence is derived power for the operation of the electrical transmission plant of the Blue Lakes Water Company.

Part 1

THE WATER SUPPLY.

The Blue Lakes, so picturesquely situated as shown near the summit of the Sierra Nevada Mountains, together with auxiliary reservoirs, both in Alpine and Amador Counties, discharging into the tributaries of the North Fork of the Mokelumne River, are the chief sources of this water supply. These sources, owned and controlled by the company, consist of (1), the Upper or

West Blue Lake, which is a deep mountain lake of fresh pure water, situated at an elevation of 8,109 feet above sea level, and which, in its original condition, comprised 230 acres, but in 1887 there was finished across its outlet a solid masonry dam, having a length of 250 feet on top, a width of 50 feet on the bottom, a width of 30 feet on top and an extreme height of 25 feet, which increased the flooded area to 375 acres.

FROM THIS SUMMIT THE INITIAL ILLUSTRATION WAS PHOTOGRAPHED.

(2) Lower Blue Lake is two miles south of Upper Blue Lake and the latter empties into it through a stream having a fall of about ninety feet. Its area is about 160 acres, its elevation is 8,012 feet and it is confined by a dam of crib work with earth filling, having a crest of 750 feet, a bottom width of 50 feet, a top width of 40 feet and an extreme height of 30 feet.

THERE'S TROUT-FISHING BETWEEN THESE ROCKS.

The catchment area drained by these two Blue Lakes is, by actual survey, 3050 acres and the surplus water from it, after filling the lakes, is discharged into Blue Creek and flows through Clover Valley to its junction with Deer Creek, thence into the North Fork of Mokelumne River and down its steep rocky bed for a distance of 40 miles, where the water is diverted into the Amador Canal at an elevation of 2,240 feet.

Supplemental sources of water supply and the reservoirs of the system consists of, (3) the Twin Lakes, united into a single body of water by a dam at their outlet on the northwesterly side. These are but one-half mile in a westerly direction from the Lower Blue Lake dam, and their area when full is 160 acres with a water shed of 900 acres. The dam is a short and solid structure, founded on granite and is made with front and back retaining walls of dry masonry with earth filling. It is of sufficient dimensions to raise the surface of these lakes 20 feet vertically. The water is discharged from Twin Lakes into a stream which flows down to Lake Valley or Meadow Lake, thence into the North Fork of the Mokelumne River.

(4.) Meadow Lake, or Lake Valley, is an artificial reservoir about three miles westerly from Twin Lakes and nearly 450 feet below them in elevation. It was formed by throwing a 450-foot dam across the westerly end of an immense granite basin, otherwise completely surrounded by mountains of great height, forming a portion of the route of Meadow Creek, which is a tributary of the North Fork of the Mokelumne River. The drainage area of Meadow Lake comprises over two thousand acres and floods about 150 acres with the present 25-foot dam.

A CHARACTERISTIC VIEW OF THE CATCHMENT AREA.

GRANITE LAKE

(5.) Bear River reservior was formed by the building of a dam of heavy masonry with a cemented rubble core across the Bear River, which is a tributary of the North Fork of the Mokelumne River. This dam is curved up stream in the form of an arch and abuts against the granite walls of the canyon. Its altitude is 5,670 feet and its drainage area is over twelve square miles.

The above list of lakes and reservoirs includes those now improved and which form a part of the system of water supply of the Blue Lakes Water Company. In addition to these storage reservoirs, further reservoir sites and water rights have been located and appropriated for future use when the demands of the company shall require additional storage facilities, and among these are the Deer Valley site, which is three miles below the dam of Lower Blue Lake, the Grouse Valley site, the Snow Valley site, Granite Lake, Bear River, Lower Bear River, and Cold Creek. Concerning these reservoir sites it is interesting to note that the waste waters from the two Blue Lakes and also the flow from Indian Creek, and a number of small lakes in Indian Valley pass through the site of Deer Valley reservoir. At the southeasterly end of the valley, granite bluffs approach to within a short distance from each other on either side of the stream and afford excellent abutments for a high masonry dam. With a dam 100 feet in height the proposed Deer Valley resevoir would impound nearly three thousand million gallons. The remaining reservoir sites are equally fortunate as to locations, and in each of them excellent building materials are on the ground or close at hand.

Twin Lakes.

Various data concerning the principal Alpine reservoirs are presented in the accompanying table on page 5.

The reservoirs now in operation, together with the reservoir sites located by the Blue Lakes Water Company are situated on tributaries on the North Fork of the Mokelumne River. The lakes and reservoirs are held in reserve and are drawn upon only during the four months each year constituting the dry season. After that period and until the summer months of the following year, the melting snow and the prevailing rains flood the streams and tributaries of the North Fork of the Mokelumne River, furnishing a supply at the head of the Amador Canal, which is greatly in excess of all possible demands. The bed of the Mokelumne river is practically of solid granite throughout almost the entire portion used as water-way for supplying the Amador Canal. The Mokelumne River Canyon is deep and precipitous, and being of granite formation there is practically no loss of water from seepage and but little loss from evaporation from the lakes to the headgates of the Amador Canal.

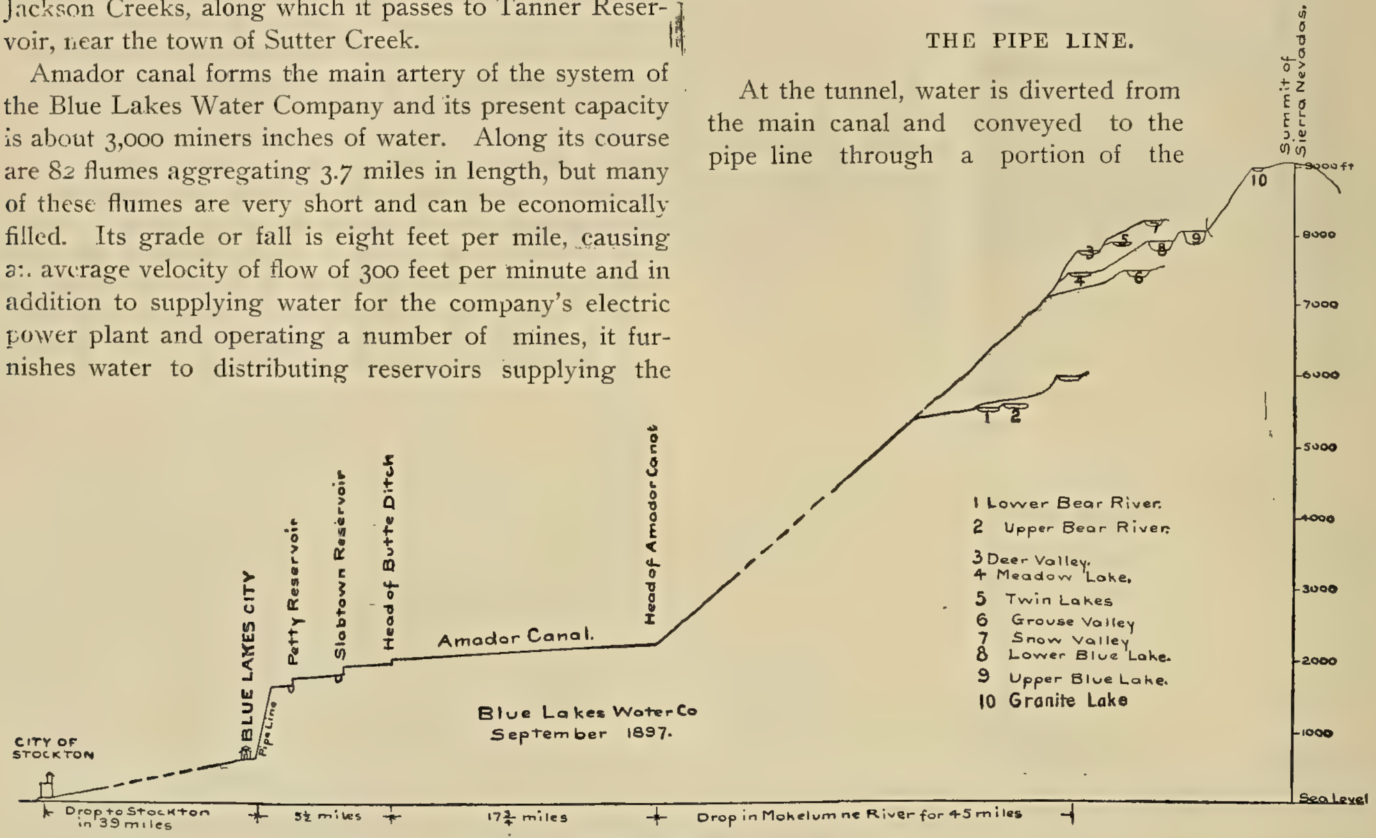
Lower Blue Lake.

Part ii

THE CANAL SYSTEM.

Strictly speaking the canal supplying water for the operation of the Blue Lakes system originates as above stated, in Blue Creek, forming the outlet of Blue Lakes, whence it flows through Clover Valley into Deer Creek, thence into the North Fork of the Mokelumne River, along which it runs for a distance of forty miles to the point where the water is diverted into the Amador Canal. For this distance, therefore, the water follows a natural course and during the dry season of the year the only water which comes down the Mokelumne River is that which is allowed to run into it from the reservoirs of the Blue Lakes system. The Amador canal is 42½ miles in length, nearly one-half of which lies along the steep rocky slopes of the main canyon of the Mokelumne River. Eighteen miles below the head gate the canal turns abruptly to the north, passing through a short tunnel and emerging upon the other side of a divide where it enters into a country of very different character. As the canal has a southerly exposure along the river side, such snow as falls quickly melts and the canal is never blocked with snow or ice. Eight miles below the head gates the canal passes around a bare granite cliff known as Bald Rock, in a wooden flume one mile in length. From the head works to the foot of Bald Rock, the general character of the country is granitic; between Bald Rock and the tunnel it passes through a formation of slate, while below the tunnel to the end of the canal the earth is of clay and gravel, forming an excellent ground for ditching purposes. Beyond the tunnel the canal winds around the slopes and head branches of the valley of Jackson Creek at a height of 400 to 500 feet above the level of Jackson until it reaches Summit Ridge, between Sutter and Jackson Creeks, along which it passes to Tanner Reservoir, near the town of Sutter Creek.

Amador canal forms the main artery of the system of the Blue Lakes Water Company and its present capacity is about 3,000 miners inches of water. Along its course are 82 flumes aggregating 3.7 miles in length, but many of these flumes are very short and can be economically filled. Its grade or fall is eight feet per mile, causing an average velocity of flow of 300 feet per minute and in addition to supplying water for the company's electric power plant and operating a number of mines, it furnishes water to distributing reservoirs supplying the towns of Jackson and Sutter Creek, Amador City, Ione and other villages.



Profile of the Blue Lakes Water System.

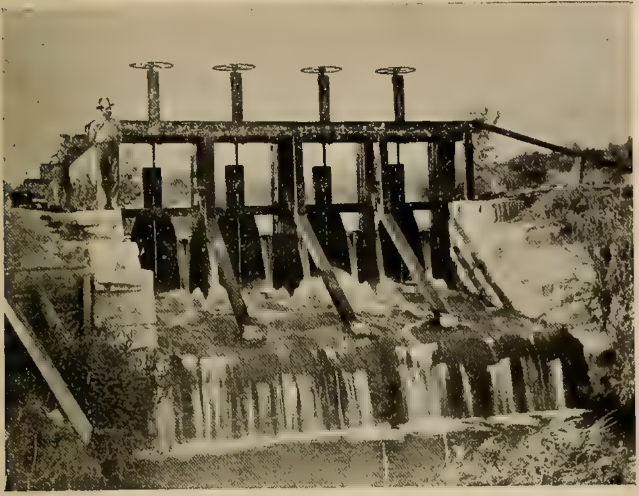
The subsidiary distributing ditches of the system consist of the Amador ditch, seven miles in length, supplying the towns of Amador and Sutter and several mines near by; the Ione ditch, sixteen miles in length and built by placer miners prior to 1859, supplying Ione City and various consumers along its line; the Kennedy ditch, supplying the Kennedy reservoir from the Tanner reservoir; the Moore ditch, nine miles in length, taking up the water discharged from the power wheels of the Kennedy mine and supplying it to the town of Jackson and to the Zeila and other mines and for irrigation purposes; the Montcherichard, Buena Vista, Newton, St. Mary's and Plymouth ditches, built for quartz and placer mining purposes, but which are no longer used; the Donnelly ditch, supplying water from the power wheels of the South Eureka hoist to the Donnelly reservoir, and lastly the Butte ditch, which was built by the miners of Butte City in 1855 at a cost of $75,000. For eighteen miles Butte ditch parallels the Amador canal and being immediately below the latter, the ditch is not now used for this distance. Below the tunnel of the Amador Canal, however, the ditches take different directions and the Butte ditch, with its ramifications, was for many years used as a distributing ditch for the Amador Canal, but the Butte ditch is now used for supplying water to the reservoir whence is derived the power for the operation of the Blue Lakes electric plant.

Part iii

THE PIPE LINE.

At the tunnel, water is diverted from the main canal and conveyed to the pipe line through a portion of the old Butte ditch, but much of its route has been changed and the ditch has been rebuilt and enlarged so that it is practically a new water-way. In the line of the Butte ditch are the Slabtown reservoir and the Petty reservoir, which together will ultimately contain sufficient water to run the plant at full load continuously for over a week, and in their present uncompleted state their capacity is sufficient to run the plant at full load for nearly three days. The length of Butte ditch from the tunnel to the pipe inlet is a little less than five miles and its route is along mountain tops where practical immunity from injury is assured.

The head of the pipe line is in a location that should win fame as a point of observation, for being situated more than a thousand feet above the turbulent Mokelumne River and commanding a view over rolling, wooded mountains to Stockton, thirty-nine miles away, or sometimes even to Mount Diablo, seventy miles distant, the reward which awaits the one who has the hardihood to climb the mountain, abundantly repays the exertion. The ditch proper terminates in a massive concrete structure which serves as a combined forebay and settling basin, the whole construction being of the most permanent type. A short distance above the penstock is a spillway, carrying waste water down a canyon independent from the route of the pipe line. The supply for the penstock is taken from well toward the surface of the water in the ditch and is carried through double sets of strainers before entering the pipe line. An extension made in line with the ditch itself forms the waste gate and overflow weir, the water from which is carried down another independent canyon on the opposite side of the pipe line from the canyon into which the spillway empties. This extension forms a settling basin carrying water nine feet deep, and is of course, provided with the usual mud gate for blowing off all settlings.



A Mountain Head-Gate.

From the penstock the pipe line continues a distance of 3,240 feet in an absolutely straight line, down the contour of bedrock to the "Y" branches at the power house, and which gives a head of 1042.75 feet at the wheel nozzles.

The accompanying profile of the pipe line also contains the plan of the pipe line, together with the location of the head of Butte ditch and the power plant and tail race. The first 80 feet of the pipe line consists of from 48 inch to 24 inch steel slip joint pipe, of No. 8 and No. 10 steel; then follows 760 feet of 24 inch steel slip joint pipe, the first two-thirds of which is laid at a grade of 39 per cent, the remaining third being at a grade of 1 per cent. The next 200 feet of pipe line is of riveted steel pipe, joined by cast steel flanges and having an inside diameter of 24 inches and ranging in thickness from 1-4 to 1-16 in. About in the center of this section begins a grade of 47.5 per cent, which continues for about a third of the ensuing section (the remaining grade of which is at 22 per cent) consisting of 700 feet of riveted steel pipe having an inside diameter of 22 inches. The final section consists of 1,500 feet of lap welded steel pipe, having an outside diameter of 22 inches, and containing four grades of practically equal length, consisting of 39.2 per cent, 66 per cent, 32.6 per cent and 41 per cent from the top respectively. The "Y" branches embody a length of 16 1-3 feet in the pipe line, whence follows the pipes leading to the water wheels independently, consisting of steel lap welded pipe, having an outside diameter of 16 inches and the greatest length of which is $58\frac{1}{2}$ feet. The elevation of the floor of the power house is 624 feet above sea level, the nozzles are at an elevation of 626 feet. The lower section consists of lap welded steel pipe, having a thickness of $\frac{3}{8}$ of an inch to $\frac{1}{2}$ an inch. Cast iron male and female flanges are used, the female end pointing up hill and the heaviest section weighing $1\frac{1}{2}$ tons. Sheet lead gaskets are used under a compression which reduces the thickness of the lead from $\frac{1}{8}$ of an inch down to 1-9 of an inch. Sections of 15-inch pipe joined with 14 bolts, using lead gaskets after this manner remained tight under hydrostatic test until a pressure of 1,200 pounds per square inch was reached.

The accompanying views illustrate some of the interesting conditions under which the pipe line was laid. The mountain is practically of rock surfaced with soil that along the route of the pipe line is of various thicknesses up to 25 feet. Soil of this nature is more or less treacherous in wet weather, and to prevent any possibility of the pipe line being carried away by land slides, it was determined to not only lay it on bedrock throughout its entire length, but also to cement it thereto. Some of the difficulties attending this work are here illustrated, but the most serious obstacle occurred in making the cut shown in the view on page 9, which is about 25 feet in depth. The loose, treacherous character of the soil made it hazardous to dig the trench without spragging it with heavy timbers, as is done in mining. The pipe line is underground for its entire length, which so supports it that crushing from atmospheric shock is believed to be impossible. The trench for about 400 feet at the lower end of the pipe line was blasted out of solid rock and

Data Concerning the Principal Alpine Reservoirs.

RESERVOIRS.			DAMS.			Storage Cap'ty of Reservoir in Mill'on Gals.
Names.	Area of Catchment Basin in sq. Miles	Area of Reservoir in Acres.	Maximum Height in Feet.	Length on Top in Feet.	Cement Masonry in Cubic Yards.	
Upper Blue Lake.	3	440	42	900	8,181	3,000
Lower Blue Lake.	2	200	49	1,003	8,556	1,777
Twin Lakes......	1.5	160	26	1,488	4,869	585
Meadow Lake....	4.5	168	70	620	10,190	2,750
Upper Bear River	12	159	70	710	12,600	2,470
Lower Bear River	13	295	70	1,670	24,800	3,940
Cold Creek.......	20	275	70	1,220	25,320	3,560
Deer Valley......	11	...	102	......	......	2,860

Total Storage Capacity: 20,942 million gallons.

after being laid therein the pipe for this distance was cemented in place with concrete filling and in addition the entire length of the pipe line from a point about a third of the distance from the top was anchored to bedrock by being cemented thereto by concrete at each joint pit. A more perfect method of preventing slippage in the pipe line could hardly be conceived. The lower end of the pipe line terminates, as stated, in three cast steel "Y" branches which lead direct to the water wheels. These "Y" castings are of half-inch, open hearth steel, having a tensile strength of 60,000 pounds and weighing 2,400 lbs., 2,500 lbs. and 2,700 lbs. respectively.

The problem of delivering the pipe along the line was solved by first digging the trench to bedrock and then hauling the pipe sections two by two over the route on a small cart pulled up by means of a rope of 3-8 inch steel wound on the drum of a logging engine located at the foot of the hill. This cart was four-wheeled and mounted on independent axles, generally so placed that the greater part of the load was borne by the rear axles, while the front wheels were provided with a tongue, by means of which two laborers steered the vehicle along its proper course. The rear truck was equipped with a system of toggle levers controlling a chain and saddle that secured the pipe firmly to the truck.

AT THE HEAD OF AMADOR CANAL.

Part iv

THE POWER HOUSE.

It is a sixteen-mile stage ride from the railroad terminus at Valley Spring to Blue Lakes City, as the little settlement at the power house has been named, and it is a ride of oft-recurring interest. One is interested in winding his way up the tortuous foothills of the great Sierra Nevadas; he is interested in the unexpected panoramic bursts of dale and forest and mountain scenery, and too often indeed is he interested in speculating upon the chances of life or death from the rude treatment of the relentless stage coach as it devil-may-cares its caloused, wicked way madly over the be-bouldered roads. It is then, if he be a solitary passenger, that one is interested in determining whether he has, by some black magic, become transformed into a battering ram and pile driver mechanism, alternately. Wondrous indeed is the flint-heartedness of the driver; yet more wondrous is it that flesh and blood survives the ordeal and emerges therefrom in a condition other than that of jellied concretion.

The scenes change quickly and at last hope rises when from off a great elevation one looks across a charming landscape and sees, eight miles away, a clearly defined line run down a mountain side as true as though drawn on the living picture by a ruler. It is the pipe line. Straight ahead and four miles below is the town of Mokelumne Hill, and down, down the mountain road the stage bumps one and thumps one until, when at last the town is reached, the solitary passenger can not but think, "Why call the town a 'Hill' when it is half way down to perdition?" and then he is liable to satisfy himself with the thought that the original name must have been refined by using the vowel next down the scale, so that it becomes, as now, Mokelumne "Hill." But the delusion that the town was misnamed does not linger long, for, in continuing on to the destination, the conveyance suddenly commences to drop, and drop it continues to for two miles further down one of the bluffest, roughest, toughest hills that man or beast ever dared to tempt Fate by traveling. Then, Blue Lakes City, where the dust begrimed traveler offers the sincerest of thanksgivings that he is all there.

The power house is located about one-half mile above Big Bar Bridge, which is on the well-traveled thoroughfare connecting Mokelumne Hill with Jackson and the other cities in Amador County. The country is the scene of the unparalleled mining activity that will be ever memorable in history as the territory worked by the indomitable miners of "the days of old, the days of gold, the days of '49." On every hand the scenes of their activity are indelibily impressed and in traversing the country one becomes dumbfounded in contemplation of the amount of work performed in the search for the untold treasure that was there but was loosely hidden. Hundreds and hundreds of thousands of tons of soil were turned over, shovelful by shovelful; mountain-side after mountain-side was washed down and "panned"; scores upon scores of claims were worked, abandoned and then reworked, finally to pass into other hands to be worked again, while in many locations prospectors' tunnels are more plentiful than were ever rabbit burrows. To-day, but little more than the surface has been mined and deep in the earth, within easy power-transmission distance from the Blue Lakes plant, is hidden golden treasure that only the ingenuity and labor of generations can exhaust.

THE FLUME AT BALD ROCK.

The power house containing the machinery that will be indispensable in the development and future working of the region, consists of a most substantial building, 35x100 feet in size and but one-half of which is now utilized. The illustrations presented, together with the outline drawings on pages 14 and 15 are comprehensive. The cap stones of the building are at an elevation of 630 feet above sea level and the structure is longitudinally divided into two floors, the upper or switchboard floor being 2½ feet above, and the lower or generator floor being six feet below the surface of the cap stones. The north side of the power house site was blasted from solid granite, and the whole structure is built on the same bedrock. The generator and water wheel foundations rest on granite at a depth of 9 feet, as do also the piers supporting the steel columns. These piers are of rich concrete and the spaces between them are filled in with stone masonry laid with cement joints. The building proper consists of a steel frame over which is placed a wire netting covering all sides and the roof. This netting supports two layers of asbestos paper, then two layers of tarred paper and finally heavy corrugated iron, which construction affords the surest safeguard against condensation. A ten-ton steel traveling crane traverses the length of the building and the interior of the station, being painted white, presents a most pleasing appearance. The ideal compactness of the generator and water wheel sets forms the most striking feature of the installation. These are placed 3½ feet apart and each unit of 600 horse power is contained in a space measuring 11½ by 12 by 7 feet.

In addition to the power house and the cottages of its employees, Blue Lakes City contains the general offices of the operating department of the extensive system of the Blue Lakes Water Company. The entire system is connected by over 120 miles of private telephone lines and the Bell Company is now extending its long distance service to the new town. Recently the hill back of the settlement has been terraced and put in grass, flowers and fruit trees have been set out, and without doubt at Blue Lakes City is to be found the most attractive power house site of any transmission plant on the Pacific Coast.

A FLUME OF THE AMADOR CANAL.

Part v

THE HYDRAULIC PLANT.

The water is led from the "Y" castings to the wheels through steel pipes, having an internal diameter of 15 inches, with a thickness of ½ inch and tested up to 1,000 lbs. These terminate in the main gates appearing at the left of the wheels in the illustrations on page 19, and the gates present the novel feature of being self-contained and having no packing. Each is a single gate operated by a worm and worm wheel, the worm wheel acting as a nut on the valve stem for raising or lowering the valve, and the worm wheel and worm being encased in the upper part of the valve proper with a vertical cylinder above which provides for the valve stem when it lifts. The entire inside portion containing the valve gearing is exposed to pressure, which eliminates the use of packing and in simplifying the construction, makes the value most compact. From the head gates the water is led direct to the quadruple nozzles of each of the three four-foot Doble water wheels constituting the hydraulic plant. These wheels are run at 600 revolutions per minute, are rated at 700 horse power and, as the illustrations show, are incased in cast iron housings which present an unusually neat appearance and as a result of which the wheels run with unusual quietness.

Direct connected to each one of the water wheels is a 450 kilowatt Stanley, two-phase inductor type generator and the marked innovation of carrying the entire set consisting of water wheel, inductor and fly-wheel, on two bearings so that the water- and fly-wheel overhang, affords one of the most radical departures in transmission practice to be found on the Pacific Coast. Indeed the symmetry and compactness of the plant is most pleasing, for, as is shown in the sectional drawing of the station, the generators are but 15 feet between centers and the three units of 600 horse power each occupy space over all of but thirty feet between the centers of the outside machines.

It is difficult to understand the ground for objections that have been made to the mounting of the Blue Lakes generators and water wheels. Overhanging bearings are used in steamship practice, which constitutes the heaviest work known to engineering. The armature of the 800 kilowatt generator of the Los Angeles Railway Company, together with the two crank discs and the hub of the fly- wheel, weigh together 98,000 lbs. and are mounted on a single shaft. In addition to this must be added the weight of the fly wheel, which is 45,000 lbs., making a total weight of 143,000 lbs., borne on a single shaft supported by two bearings. Moreover, a shaft driven by two engines having quartered stroke is subjected to complex strains of an infinitely more trying nature than is the shaft sustaining a water wheel giving a constant, even torque.

At the Head of the Pipe Line.

Hauling Pipe Up the Pipe Line Grade.

Hauling Pipe with a Ten-Mule Team.

The weight on the shafts of the Blue Lakes equipment is but 20,000 lbs., of which the water wheel weighs 2,000 lbs., the inductor 14,000 lbs., and the fly wheel 4,000 lbs., from which it appears that the alleged objections to overhanging bearings can hardly be of a mechanical nature. Moreover, the stresses on a shaft which is not supported by overhanging bearings, but is sustained at its ends, are similar to those of a beam weighted in the center and from which must result a tendency to sag. With overhanging bearings, however, the shaft becomes as two cantilevers with overhanging weights opposing that in the center of the shaft, thereby restricting the tendency to sag. Two exciter sets each consisting of an 18 inch Doble wheel direct connected to a 10 horse-power dynamo, are located on solid concrete piers directly behind the generators. These wheels are also provided with cast iron housings and, in addition, the frame contains a plate glass panel for viewing the action of the water on the buckets.

Another interesting feature of the hydraulic equipment lies in the use of strainers for the jets of the exciter wheels. These strainers, which are of solid cast iron construction and located on the fronts of the concrete piers immediately below the wheels, may be compared in action to that of a two way valve in that the water for driving the wheel may be instantly made to flow through either one of two courses. These courses are each provided with a strainer of brass gauze so mounted in cartridge form as to be easily removable, and the principle of operation of the apparatus lies in the feature it embodies for permitting the removal and cleaning of one strainer cartridge while the other strainer is in use. Some such arrangement is necessary for the protection of small nozzles using water under high heads in plants where the water may possibly contain twigs or leaves or bits of wood that might cause a shut down because of closing the small orifice in the jet of the exciter wheel. The jets of the large wheels, having greater orifices than the area of the screen openings are not liable to clogging from this cause.

The Big Cut in the Pipe Line Trench.

From a strictly hydraulic standpoint, the most novel feature in the Blue Lakes plant is the absence of both receiver and air chamber on the pipe line. Accidents that have occurred to pipe lines have been due to water ram caused by the almost instantaneous opening and closing of gates or by collapse due to the formation of a vacuum caused by a choking at the intake or the using or escape of water at the lower end faster than it can possibly enter from the forebay. The gates in the Blue Lakes plant are so constructed that it is a physical impossibility to open or close the main gate in less than ten minutes, nor can either of the quadruple nozzles be closed or opened in less than three minutes, which arrangement it is believed allows sufficient time interval to elapse to prevent any possibility of water ram. The pipe line is without air valves in any portion, but the factor of safety in the materials used is so great and the pipe line is so deeply buried throughout its entire length and so rigidly cemented to bedrock by concrete, and as all parts before installation were subjected to a hydrostatic test of not less than double the working pressure, it is believed that breakage and the draining of the pipe sufficient to cause collapse from atmospheric shock, is an impossibility. At present the water wheels are running by hand regulation, but governors will be installed shortly and so arranged that two nozzles of each water wheel will be hooded by the governor and the remaining two will be throttled by hand should occasion require. From the wheel pits the discharged water is carried in individual courses to the tail race, whence it continues underground through an arched tunnel under the grounds of the power house, emptying into the Mokelumne river.

Part vi

THE ELECTRIC PLANT.

The generating station apparatus consists of three 450 kilowatt, two-phase, Stanley inductor-type generators, running at 600 revolutions per minute and delivering current at 7200 alternations per minute, at a potential that may be varied from 2000 to 2400 volts. These are mounted on two bearings with direct connected overhanging water and fly wheels as previously described. The exciters consist of two 10 horse power multipolar generators, delivering current at 60 volts and either of which has sufficient capacity for exciting the fields of the three 600 horse power generators. The generators are, of course, too well known to require detailed description, but the switchboard presents modifications of design that were necessary to satisfy local conditions.

Two sets of bus-bars are provided and the switchboard combinations are such that through four-pole double throw switches, either generator may be thrown on either set of bus-bars; or through four pole double throw switches, either recording wattmeter may be thrown on either set of bus-bars; or either generator may operate either line individually through its proper recording wattmeter; or all generators may be connected in parallel, feeding either or both sets of bus-bars—in brief, any desirable combination between generators, bus-bars, and transmission lines may be effected.

LAYING THE PIPE LINE.

Under a contract existing between the Blue Lakes Water Company and the California Exploration Company, the Exploration Company has the exclusive right to use and sell electric power from the Blue Lakes plant in Calaveras County. As the Mokelumne River forms the dividing line between the two counties, the plant is admirably situated for the execution of this agreement. At present two transmission circuits are carried from the power house, namely the Amador and Calaveras circuits.

The switchboard consists of ten panels, the first three of which, beginning the enumeration from the left, are for generators 3, 2 and 1 respectively, after which follows the exciter panel. Panels numbered 5 and 6 are for the Thomson recording wattmeters on the Calaveras and Amador circuits respectively. Then follows panel 7 for the 10,000 volt Amador County line; panel 8 for a supplementary Amador County transmission circuit; panel 9 for the Calaveras County circuit, while panel 10 is a blank, eventually to be used for the proposed transmission to Stockton. The arrangement of the switchboard and transformer features is unique, for, as shown in the sectional view on page 14, the transformers are to be mounted on a platform erected over the enclosure back of the switchboard. Down this enclosure has been constructed a skeleton board on which is run the high potential switches and circuits, all as indicated in the sectional drawing. At present the step-up transformers have not been placed in service but the generator potential of 2400 volts is put to the transmission circuits direct. Before spring, however, the step-up transformers will be installed and 11,000 volts will be put to line.

From the high potential switchboard the line circuits are carried up the wall back of the transformers and across beneath the roof, thence through the choking coils, whence they pass out to line as shown in the accompanying illustration. At the peak of the roof a choking coil measuring about 24 inches in diameter and containing 205 feet of No. 3 insulated wire is cut into each line. The lightning arresters are tapped on to the lines after leaving the choke coils, and are of the latest form of the Wirt alternating current short gap type, each of which is designed for 2,000 volts and therefore, each line has five such arresters connected in series. These arresters have only two 1-32nd inch gaps between the primary and ground, and the arrester is grounded through a graphite resistance of 400 ohms. The principle of the device is that the arc is extinguished upon reversal of the current by the cooling effects of large metal cylinders and the current is limited on short circuit by the low non-inductive resistance.

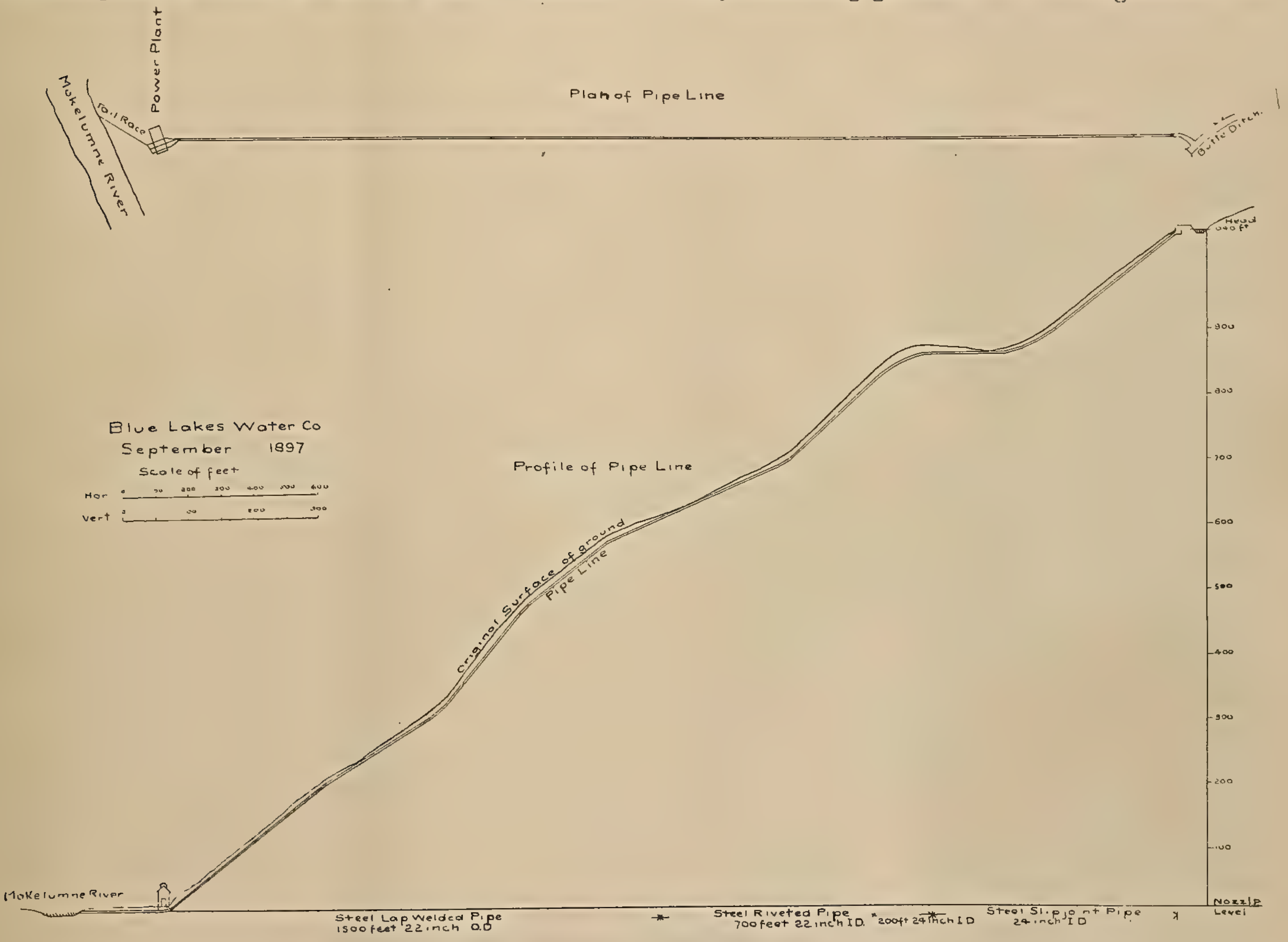
THE "Y" CASTINGS AT THE POWER HOUSE.

The mode of synchronizing three-phasers and the circuit connections by which this is ordinarily accomplished have been described heretofore,* and while the synchronizing of two-phase alternators is effected through the same general lines of procedure, its circuit connections are different in many respects. The means by which synchronism is attained in the two-phasers of the Blue Lakes plant are shown in the diagram appearing on page 20.

Inasmuch as in polyphase alternators the phases are fixed in relation to each other, it is only necessary in the two-phase system to take but one phase of each generator to the synchronizing apparatus on the switchboard and this phase is always the leading phase. The leading phase of each generator, therefore, supplies current to the 2000-volt transformer appearing on its respective panel, and these transformers reduce from 2000 volts to 50 volts and have a capacity of 500 watts. The only portion of the synchronizing equipment that appears on the front of the switchboard is a small U-plug switch, by means of which the circuit combinations of the secondaries of the synchronizing transformers are changed, and three pilot lamps on each of the three generator panels. The center lamp in each case is an ordinary 50-volt pilot lamp for indicating that the dynamo is in operation and the remaining two outside lamps of each panel are 100-volt lamps for indicating synchronism between its particular generator and either of the other two generators. Referring to panel No. 1 of the accompanying diagram, for instance, the pilot lamp appearing in the center is directly connected across the secondaries of the switchboard transformer. On the lamp at the left is indicated synchronism between generator No. 1 and generator No. 3, while the lamp at the right of the panel indicates synchronism between generator No. 1 and generator No. 2 as appears on the diagram, and so on through the remaining panels.

In synchronizing generator No. 1 with generator No. 2, the U-plug is withdrawn, which cuts out the plug switch from the circuit. The pilot lamps of panels 1 and 2 are assumed to be burning, but the generators are, of course, running on independent bus-bars. The two synchronizing lamps appearing as shown on panels 1 and 2 for indicating synchronism between their respective generators, are turned on by the key sockets. This done, the circuit connections of the synchronizing equipment may be readily traced.

It is to be understood that the secondaries of transformers 1 and 2 are coupled in series and feed into the small bus-bars lettered A and B. If now generators 1

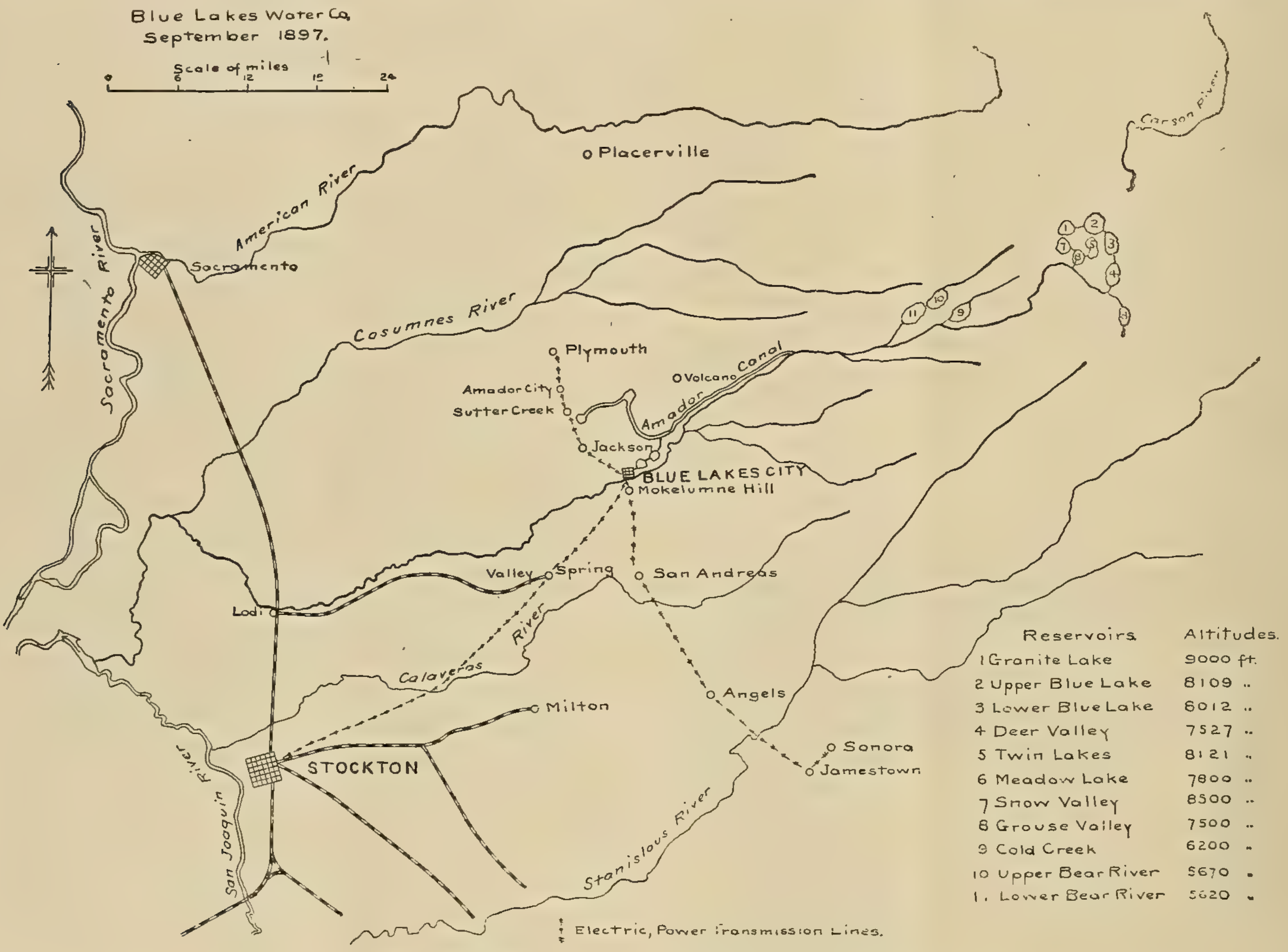


PLAN AND PROFILE OF THE PIPE LINE.

---

* The Journal of Electricity, Vol. IV, No. 1; June, 1897; Page 7.

and 2 are in synochronism the transformer secondaries will be in phase and their potential, being cumulative, will give a pressure of 100 volts across bus-bars A and B. If, however, the generators are out of step, the bus-bar potential will be reduced in direct proportion to the amount of drag in either generator. At intervals, therefore, the phases of the two transformers are in direct opposition and the bus-bars have, consequently a zero potential. In the next instant, the relative positions of the phases may have changed so that the transformers will be in but half opposition, giving a potential of say 50 volts to the bus-bars, while a fraction of a second later the phases may be in step giving full potential to the 100-volt lamps, which shows synchronism and at the instant the synchronizing lamps reach full candle-power, the main switch must be thrown to couple the generators in parallel.



The Geographical Location of the Blue Lakes Plant.

The U-plug switch is used only in synchronizing generators 1 and 3 and generators 2 and 3, and the use of the switch merely connects the secondaries of transformers 1 and 3 and transformers 2 and 3 respectively, so that the circuits shall be in the same condition as already described for synchronizing generators 1 and 2. There is but one precaution necessary to take and that is that all synchronizing lamps shall be turned off at the key socket excepting those for synchronizing; otherwise it is possible to throw a potential of 150 volts on to the synchronizing lamps of generators 1 and 3 if the U-plug is in the wrong position.

The ease and celerity with which the generators of the Blue Lakes plant are thrown in parallel is remarkable, and those who were present on the evening of the formal opening of the plant on August 25th witnessed the three generators run independently, then saw them coupled in synchronism when finally the water was cut off from the wheels of generators 1 and 2, which were run as motors for the remainder of the evening, taking two-phase current at 2400 volts from generator No. 3. Those who question the possibility of running simple inductor generators as synchronous motors, would have had their doubts forever dispelled had they witnessed the exhibition.

Part vii

THE AMADOR CIRCUIT.

The custom of selling water by the miners inch, regardless of the head at which it is delivered, is a legacy of the early mining days when water was desired for washing gold and not as a source of power. Regardless of the unfairness of charging for water used for power purposes without considering the pressure, the primitive custom is still adhered to all along the mother lode. The mills and mines are located at various altitudes and, with two or three exceptions, all are operated by water power furnished from the canals of the Blue Lakes Water Company. An average of the water consumed for power purposes by these mines shows that for each miners inch an average of but three-quarters of a horse power is produced. The electric plant generates a trifle over two and one-quarter horse power for each miners inch consumed, and it is estimated that including the usual conversion and transmission losses, power can be delivered at mines at a consumption of water equivalent to practically one miners inch per horse-power. The two or three exceptions referred to as being non-users of water power consist of mines situated at such an elevation as to render water power impracticable because of lack of head; these mines and mills use steam power for hoisting only, burning wood at a cost of from $5.00 to $6.00 per cord, and the average cost of steam power is found to be from $12.00 to $15.00 per horse-power per month. The use of coal is prohibited because of the cost of from $12.00 to $13.00 per ton delivered.

The Blue Lakes Water Company, therefore, furnishes water for practically all the power consumed by the industries of the vicinity, and now that the electric plant is in operation, it is prepared to supplant the use of water power with electric power, which in many cases presents advantages not to be found in any other form of power. It is estimated that between 1500 and 2000 horse-power is consumed or will shortly be consumed by the mines situated along the mother lode in Amador County.

The Amador circuit, after leaving the power house, follows along a private road for about a quarter of a mile to Big Bar Bridge, whence it continues up along the tortuous road climbing Butte Canyon to Butte Basin, at the base of Butte Mountain, so famous in early mining days. Passing Butte City, the pole line continues on, closely following the mother lode through the towns of Jackson and Sutter Creek and terminating in Amador City, a distance of about ten miles from the power house. Some of the most famous mines of the district are the Amador Queen, Alma, Anita, Amelia, Amador Gold Mine, Zeila, Argonaut, Kennedy, Oneida, Wildman, Mahony, South Spring Hill, South Eureka, Central Eureka, Keystone, Bunker Hill, Gover and Valparaiso mines.

The cities of Jackson, Sutter Creek and Amador have heretofore been lighted from a central station located in Sutter Creek, which was operated by water power at a head of 500 feet from the Amador canal. The Blue Lakes Water Company owns one-half interest in this lighting plant and the contract under which water was furnished for its operation gave the Blue Lakes Water Company the right to substitute electricity for the water power at its option. The change from water to electricity has been made and the cities named are now lighted from the 2400 volt generators direct, the load amounting to a maximum of 300 horse-power.

The pole line is of the most substantial type. Thirty-five foot selected redwood poles are used throughout, measuring 10x10 at the butt by 6x6 at the top, and being sunk six feet in the ground. Two twenty-two inch cross arms, gained eighteen inches between centers, are used and at curves these cross arms are doubled and framed together. All poles on curves are firmly guyed to inverted "T" guy stubs consisting generally of 8x8 redwood. Two No. 3 B. & S. gauge wires are placed on each cross arm at a separation of eighteen inches, and of the four wires carried by the two cross arms, the diagonal wires are phases. Locke triple petticoat china insulators are used throughout. The line is not transposed. At the tops of the poles, supported by porcelain knobs and grounded at irregular intervals, is run a close-barbed galvanized iron fence wire. This ground wire continues over the entire pole line and its object is to facilitate the grounding and dispersion of static

The Pipe Line Trench from Forebay to Power House.

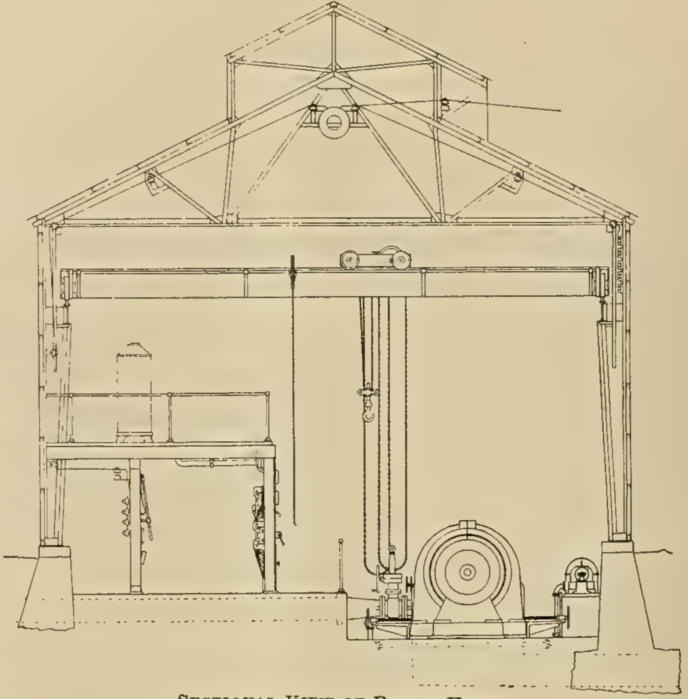
charges, thereby minimizing the liability of a lightning stroke. The country over which the Amador circuit traverses is rather a rugged one and as a result, the separation between the poles varies from a maximum of 125 feet to a minimum of 50 feet as occurs in Butte Canyon. For nearly its entire length the pole holes were blasted.

The utilization of electric power to supplant the existing sources of power in Amador County will probably furnish results of considerable engineering value. In some instances induction or synchronous motors will be belted direct to main shafts as are the water wheels at present, while in other cases smaller units will be used; for instance, one for the stamps, one for the concentrators, one for the hoists, and a fourth for the compressor. It is probable, however, that the most interesting application will be in the adaptation of steam engines for use as air motors to be driven from air compressed into steam boilers as receivers, by compressors run from two-phase motors.

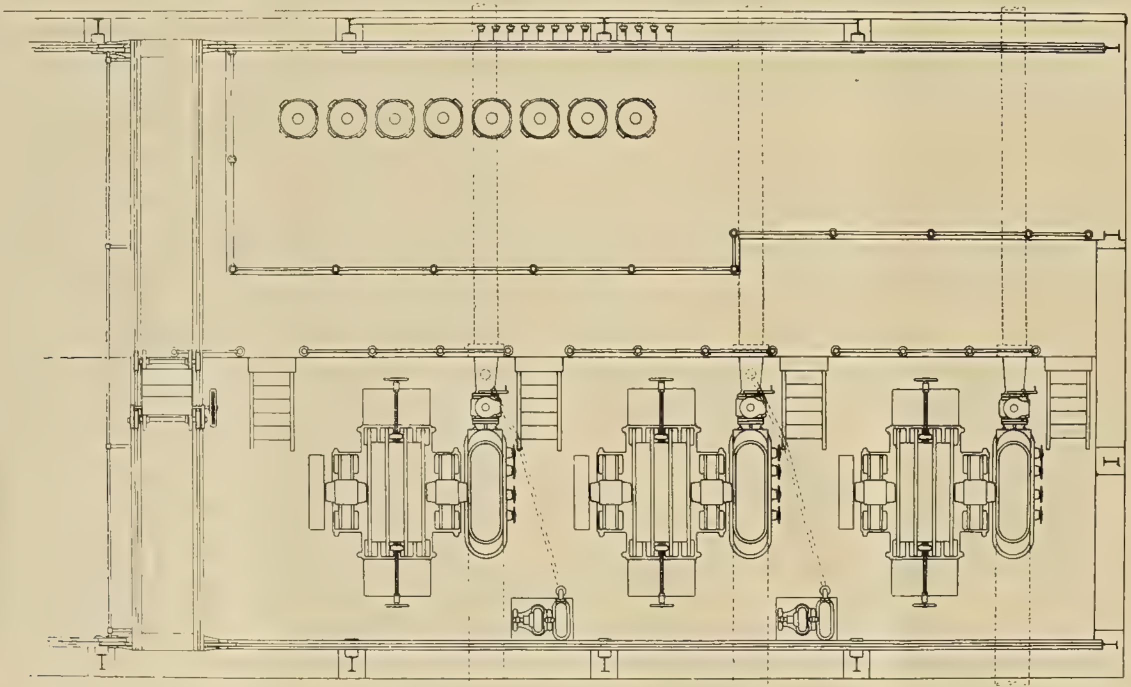
Part viii

THE CALAVERAS CIRCUIT.

The mining conditions which exist in Calaveras County differ from those of the remaining portions of the mother lode in that, although there is sufficient water for all milling and domestic purposes, there is not sufficient water available for power purposes, and to this condition may be attributed the expression of the early mining days, that "Calaveras is no good," despite the fact that the mother lode traverses it. At the north are found the magnificent properties in Amador County, while the celebrated Gwinn mine is within its confines; its central portion now holds the Gottschalk, Ford and Thorpe mines, while at the southern end are the famous properties near Angels Camp, among which are the Stickles and Utica mines, the latter bearing the distinction of being the largest gold producing mine in California. Under these conditions it was but reasonable to assume that the absence of developed mines in the central portion of Calaveras County was due to lack of water or power for working them, and not to poverty of the mother lode.



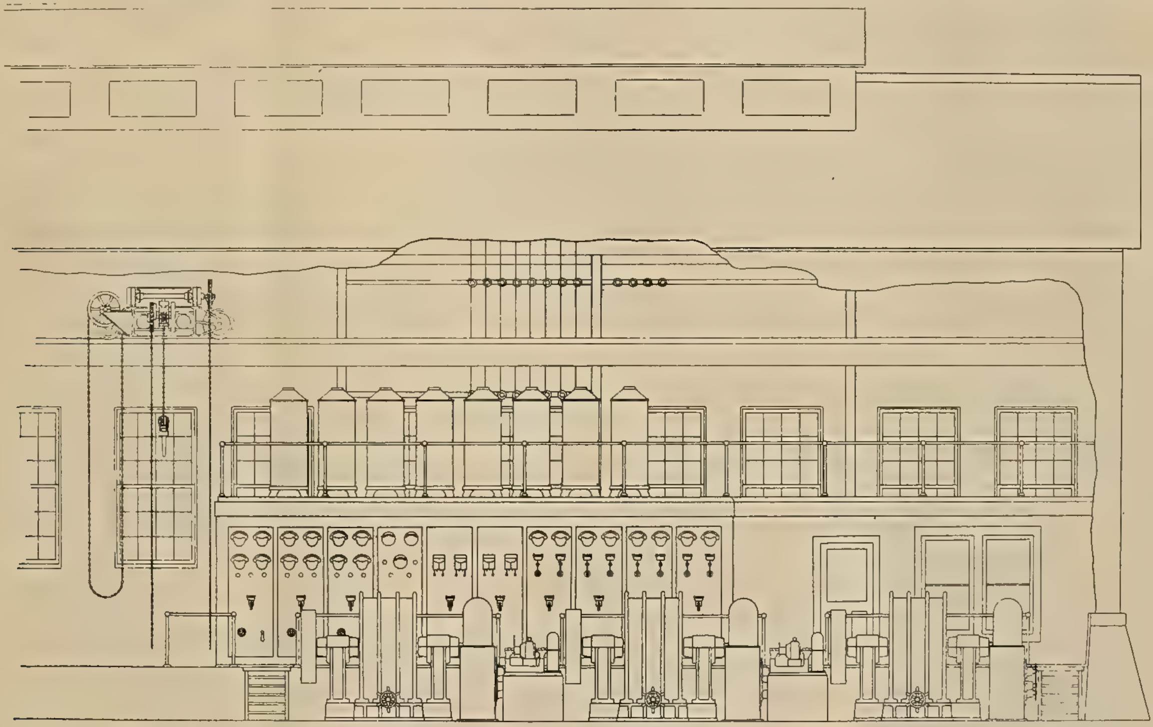
Sectional View of Power House.



Ground Plan of the Power House.

These were the conclusions which led Prince Poniatowski, Mr. W. H. Crocker and others, to bond over a score of mining properties situated on the mother lode between Mokelumne Hill and Angels Camp, the outcome of which was the interesting of English capital in the development of the properties of the Company. The first move of the English members of this corporation was to secure the services of Mr. Richard A. Parker, E. M., C. E., to report upon the Calaveras properties thus acquired, and Mr. Parker's report was so favorable that active operations were begun at once toward the exploration and development of the properties. These, however, have now been increased until they number over thirty.

With a few exceptions the only mines that have been operated in the central portions of Calaveras County have been surface workings, not the least noteworthy of which was the famous Chile Gulch. The cost of development in this region has been high on account of the expense for fuel, which ranges from $4.50 to $5.50 per cord, and without water power, and with high charges for wood, mine development has been possible only for wealthy corporations.


Transverse Section of the Power House.

After an exhaustive study of the means available for furnishing power for the exploration and operation of its mines, and after a thorough canvass of the various water powers available, the California Exploration Company resolved upon electricity as the most feasible power and entered into a thirty years' contract with the Blue Lakes Water Company under which the Exploration Company has the exclusive right for the transmission and distribution of electric power and light from the Blue Lakes plant in Calaveras County. This contract contemplates the use of from 1000 horse-power up, and really forms the basis for the building of the Blue Lakes plant.

The only distinction between the Amador and Calaveras pole lines is that the latter passes over the less rugged country; but otherwise, and in the matter of poles and materials the Calaveras circuit is identical in construction with the Amador line. From the power house the line is taken up a mountain side for a distance of one mile to the Exploration Company's sub-station in Mokelumne Hill, in which town there is nine-tenths of a mile of pole line for lighting distribution purposes. The next sub-station is in the town of San Andreas, which is 7.7 miles distant by way of the pole line from the sub-station in Mokelumne Hill. The town lighting in San Andreas embraces 2.03 miles of pole lines for low tension distribution, and from the sub-station the transmission line continues on a distance of 7.05 miles to the Bund mine, to which the high potential circuit is now completed. The total length of the Exploration Company's transmission line is at present 19.11 miles, and in all probability the circuit will soon be extended to Angels Camp, which is about five miles beyond the Bund mine. At present the 2400 volt potential of the generators is delivered direct to the Calaveras circuit, as is done in Amador County, for with the exception of the lighting load in Mokelumne Hill and San Andreas, which amounts to about 100 horse power, the only load on the circuit is the twenty horse power hoist in the Gottschalk mine. Current for the operation of this hoist, is taken from the main line before reaching the San Andreas sub-station, by means of a branch power line .43 of a mile in length.

The labor cost of building the Exploration Company's transmission line forms an interesting study, and is here presented through Mr. Parker's courtesy. Some reference seems necessary, however, to the item of surveying and preliminary work in which the expense given covers three surveys made, preliminary meanderings of county roads and other outside work, all of which was incorporated into the one general item of survey during the time. Probably one-half of the amount stated would be a fair price for the actual surveying work put upon the line.

The cost of labor in the various items of construction of the Calaveras circuit, as given by the California Exploration Company in terms of per mile of line, is as follows:

Surveying and preliminary work	$95 20
Clearing line	46 16
Digging holes	50 40
Distributing poles on line	13 20
Crossarming, gaining, etc	18 00
Erecting poles	25 20
Stringing barbed wire and guying	15 14
Stringing main line	64 20
Stringing telephone line and distributing and placing brackets	15 30
Painting crossarms	9 83
Distributing insulators, crossarms, etc	15 20
Total	$367 83

General View of Blue Lakes City.

Part ix

FINANCIAL.

The Blue Lakes Water Company was incorporated April 17, 1890, but did not come into possession of the properties until January 1, 1892. The capital stock is $10,000,000, divided into 100,000 shares of $100 each, par value; the amount paid in, or rather the one and only assessment was $6.00 and was paid in 1892. The company is authorized to issue $5,000,000 in bonds, and has issued $725,000 under date of March, 15, 1893, running forty-five years and bearing 6 per cent interest. The California Safe Deposit and Trust Company of San Francisco is trustee, and although the bonds are but 6 per cent, the company is not permitted to issue other bonds without demonstrating to its trustees that whatever property may be acquired through the sale of further bonds, or whatever use to which the proceeds of the sale of such further bonds may be put, shall be able to alone earn a net interest of at least seven per cent on the face value of the bonds so issued.

The company owns all the available lands surrounding the lakes and reservoirs, and along the river, canals and ditches, the titles to which are clear and correct.

The future development of the Blue Lakes plant will depend to some extent upon the growth of the mining industry along the mother lode and the near future will doubtless see the completion of the circuit to Jamestown on the south and possibly to Placerville on the north. Preliminary steps are being taken for the building of an electric railway connecting the principal cities of Amador County with the Southern Pacific at Valley Spring or Ione, while a similar line in Calaveras County has received some consideration. More probably, however, will the building of a transmission line to Stockton, thirty-nine miles distant, constitute the first important extension of the plant. The Blue Lakes Water Company at present owns and operates the Stockton Water Works system, and the operation of the water works together with that of some of the great flour mills of Stockton, as well as possibly its street railway system, will give an ample load for the proposed Stockton circuit. It is estimated that 50,000 horse power can be developed by the Blue Lakes Water Company at a cost not exceeding $100.00 per horse power for the complete plant, including further water development and all necessary pipe lines, hydraulic, electric, buildings, and other equipment.

Part x

PERSONAL.

In conclusion, personal recognition should be given to the principal individuals most directly interested in the installation question.

The orginal conception of the idea of utilizing water power from the Blue Lakes system for the operation of an electric transmission plant, and of the selection of the location for the pipe line and power house, was due to Mr. Robert McF. Doble, Secretary of the Blue Lakes Water Company, and who from the outset has had personal charge and supervision of the design, construction and installation of all details in connection with the plant, and in this work Mr. Doble was assisted by Mr. Ross Morgan, C. E., and Mr. W. Stuart-Smith, E. E.

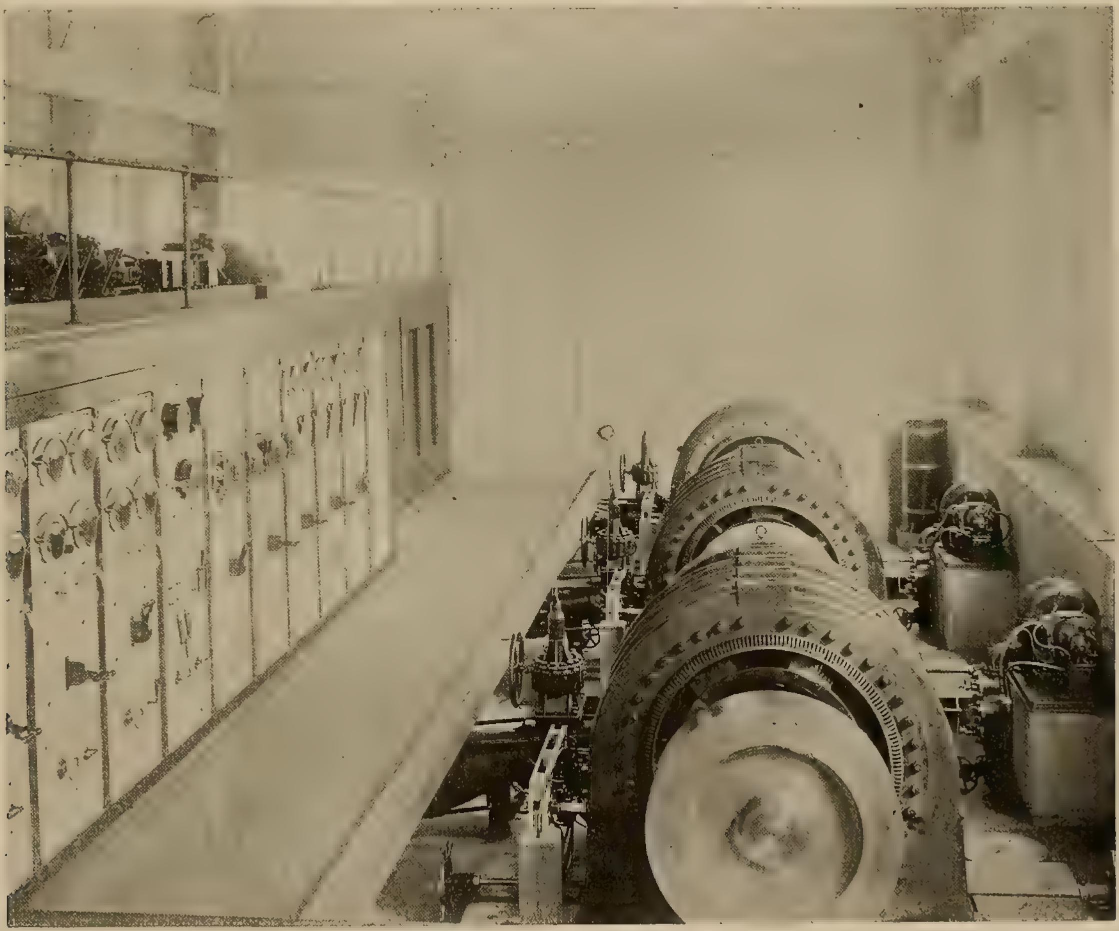
The financial features have been in the hands of Mr. W. Frank Pierce, President. Mr. Pierce and Mr. Doble, together with Mr. C. S. Wright, Vice President, Mr. Jesse W. Lilienthal, Attorney, and Mr. John Flournoy, constitute the Board of Directors of the Blue Lakes Water Company. The head office of the company is at Rooms 175-178 Crocker Building, San Francisco.

Prince Andre Foniatowski is President of the California Exploration Company, and Mr. Richard A. Parker, E. M., C. E., General Manager, with offices in the Crocker Building, San Francisco, and Mr. W. L. Honnold is General Superintendent, with offices at San Andreas, Calaveras County.

Gas

THE EXPLOSIVENESS OF ACETYLENE.

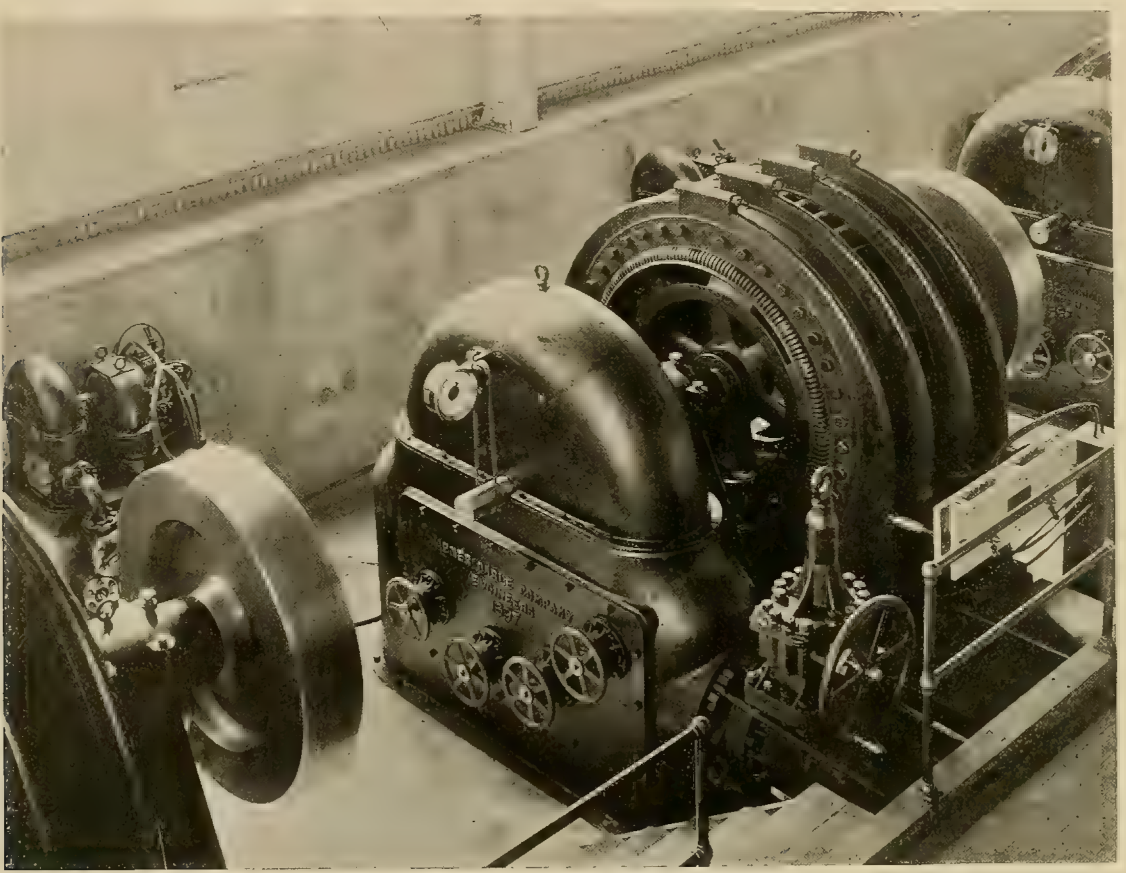
Mr. H. Schrey, in a contribution to a recent German contemporary, (Annalen fur Gewerbe und Bauwesen) states that it has been shown in experiments made by M. Ravel that 6.35 cu,. ft. of acetylene gas generate 1 horse power per hour. This is equivalent to a reduction of two-thirds as compared with petroleum. As to the explosiveness of mixtures of air and acetylene, 1.35 parts of acetylene mixed with one part of air begin to be explosive, and the explosive force of the mixture rises rapidly as the dilution with air increases, and attains a maximum when 12 volumes of air are mixed with one volume of acetylene, As the proportion of air is increased



General View of the Generator Room.

beyond this limit, the explosive force subsides, until at 20 to 1 it becomes entirely extinct. The flashing point approximates 480 degrees C., whereas in the case of most other gases used to generate power the requisite ignition temperature is about 600 degrees. The temperature of combustion is very much higher than that of the other gases with which it can be compared. Mr. L. Meyer has already called attention to the dangerous character of the explosion of acetylené mixtures. The special characteristics of this gas are accordingly: (1) Great rapidity of the transmission of flame; (2) low ignition temperature; (3) high combuston temperature; (4) extraordinary energy evolved in the explosion.

Special precautions were needed in conducting M. Ravel's investgations, as the force of the explosion was more violent than that of any other known mixture of gases. It is very dangerous to search for leakages of acetylene gas with a naked light, owing to the highly explosive character of the mixtures of this gas with air. It was found necessary with acetylene to employ twice as much lubricant for the cylinder as when using coal gas, and the cooling of the cylinder has a much more important effect upon the working of the motor than is the case with coal gas. In a small 2-horse-power motor the actual working showed that acetylene gas gave 2.1 times the work of the same volume of illuminating gas, and the contrast would be doubtless greater still in large motors. The employment of acetylene in gas engines of the type in common use would not, according to Ravel, be expedient for reasons given, but in a large engineering works in Italy some acetylene motors are being constructed for bicycles, with the intention of employing in them a mixture of one-sixteenth of acetylene to fifteen-sixteenths of atmospheric air. These motors are intended to be run at 600 revolutions per minute, and to go for 15 hours without recharging. The weight is 19.8 lb., and the working cost is set down at 12 cents per hour.



One of the Doble Wheel and Generator Sets.

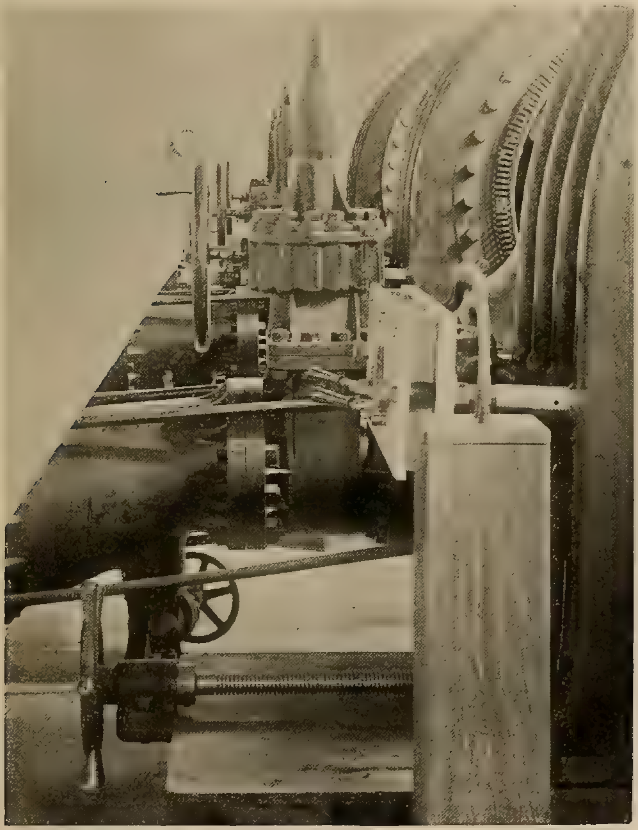
Illumination

EUROPEAN AND AMERICAN PRACTICES.

By J. McGhie.

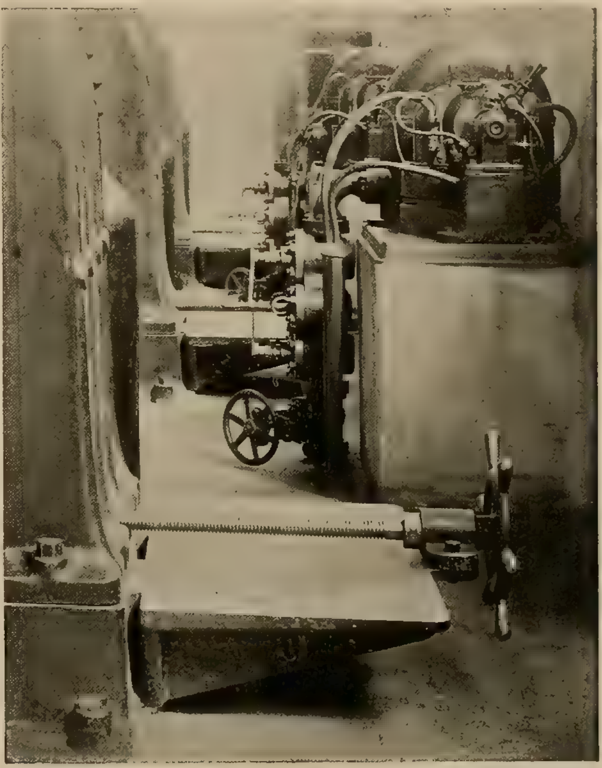
The outcome of a hurried visit to England and France is, perhaps, not so much the acquisition of the idea that both of these countries are hopelessly behind in the race, electrically speaking, with the enlightened sons of Uncle Sam, as the receipt of a very strong impression that they are much farther ahead than we have been led to suppose from the reports of the veracious foreign correspondents of the daily press. True it is that electricity has by no means become the handmaiden of daily home and business life as it has on this side of the Atlantic, but, freed from the bumble-like restrictions placed upon its adaptation by sundry parliamentary wiseacres in the early eighties, when the industry needed most encouragement, it promises to become as widespread in its use in the United Kingdom as here in the United States. The period through which this country passed some eight years ago, when the boom of electricity in the lighting as well as in the railway branches enveloped every town and hamlet, has for some time dawned in Great Britain and France, and there is plainly evident a marked avidity to acquire as soon as possible a better means of illumination than is afforded by very poor and very poisonous gas, and a better method of transit than the poorer horse and the hearse-like tramcar.

The lack of private initiative, however, which has prevailed during the past few years is strikingly apparent. Under the Governmental restrictions imposed upon it, electricity as a field for investment presented few or no inducements to capital, and where in the United States thousands of dollars were poured out for the puropse of installing stations and spreading the use of the current, it seems to the ordinary observer that in England and France pennies only have been invested, and those with a niggardly hand and suspicious mind. The confidence in the future universal use of electricity which characterized the pioneers on this side seems to have been almost entirely absent from the minds of the men on the other; and that which is here termed European conservatism is simply either a pure lack of appreciation on the part of the English or French, or a determination to do nothing until, by the experience gained in the United States, capital could see its way clear to the assurance of a profitable return. Any lack of appreciation, however, is rapidly giving way before the active propaganda now being carried on. Indeed, it may be said to have already made way for a very lively realization of the positive benefits to be derived from the use of electricity—a realization of which certain American companies, with an eye kept vigilantly open for future business in Europe, have already taken advantage.



THE MAIN GATE VALVES.

To glance over the list of projected companies having the utilization of electricity as a basis for their appeal to the public in England, that country of easy flotations, is calculated to make one believe that the electrical millennium is near at hand. Hardly a city or town, however important, or a little Peddlington, however insignificant, but is desirious of having a station within its limits, and if the public were as sanguine as the promoters there is little doubt that the boom of electricity would assume overwhelming dimensions. It is, perhaps, fortunate that the mysterious "je ne sais quio" which to the untutored envelopes all things electrical is still unpenetrated by the general public, otherwise England would probably see another panic such as was caused by the collapse of the great boom in the early days of railways. In view of this, an immediate widespread extension may not, therefore, be looked for, but instead a healthier, steady, and cautious increase.



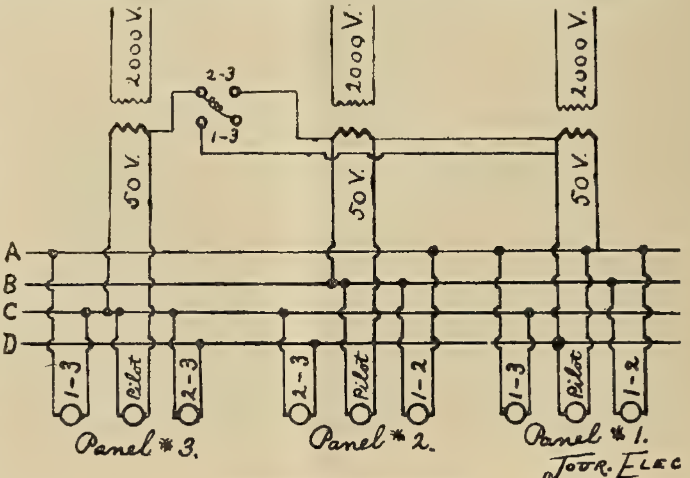
THE EXCITER SETS—SHOWING THE STRAINERS.

It is not until the visitor has left Liverpool, where he lands, that the still chary use of electricity makes itself felt. The first impression gained from a view and a trip over the Liverpool Overhead Railway is that he has dropped among a distinctly electrical people. Here is a road which enjoys the distinction of being the first permanent elevated electric railway in the world, between six and seven miles long, running the entire length of the magnificent estate of the Mersey Docks and Harbour Board, from the Dingle to Seaforth. It is run without hitch or accident, and traveling upon it is a distinct pleasure. The road is phenomenally smooth, and the perfect manner in which the train service is carried on is a delight. Although this road was installed in 1893, and was preceded and followed by important subterranean electric railways in London, it is a strange fact that comparatively slow progress has been made in the adaptation of the electric motor to the street railway systems. It is as though the country had paused for breath after the exertion.

Choking Coils and Lightning Arresters.

After leaving Liverpool, electrical installations of all kinds become markedly sporadic. Electric lighting is still a luxury to be enjoyed with the pride of possession, or gingerly with the satisfaction that comes of playing with a half understood and dangerous plaything. The pushing little private company, securing with a hurrah and the expenditure of a little palm money a franchise for nothing from a venal or semivenal board of aldermen, is practically unknown. The installation of an electric lighting plant is a matter of grave concern to be approached with a seriousness befitting the case. And here is apparent the extent to which municipal socialism has crept into English city life. A large number of the electric lighting plants concerned with city lighting which have been installed are not private but municipal, owned by the city or town, and operated by the corportion officials. To the American imbued with the knowledge that any municipal plant would prove a municipal curse in the hands of the politicians—this ownership and operation of electric lighting plants by the cities themselves is a source of wonder by no means diminished by a visit to the station and an examination of the accounts. It may be the thin end of the socialistic wedge leading to eventual universal State ownership, but so far as England is concerned the apparent results are gratifying. The process by which these are obtained is simple. The decision to acquire or establish a plant by a municipality is followed by the retention of the most talented consulting engineer it can afford—such men as Dr. John Hopkinson and Prof. Kennedy, for example—and the advice of this engineer is followed and not set aside for that of some man with a pull. The estimates are honestly called for and honestly treated, and the result is without exception the purchase of the best available machinery the town can pay for. The deliberation accorded the project, though to us somewhat slow, receives its compensation in the perfection of the result achieved. The erection of the plant is followed by the engagement of a competent operating engineer, and in his appointment the role played by "inflooence" is very minor. It is not a political position to be given away as compensation for value received, and it is held so long as the incumbent behaves himself. There is no dismissal on account of political differances and no retention on account of political services. The same rule applies to all the positions connected with the station. The net result of the injection of a little honesty into these municipal matters is a plant which is the pride of the taxpayer instead of a yawning gulf of expense.

The impression gained from a visit to English or French central stations is essentially agreeable. Instead of a station containing half a dozen different makes of dynamos, some driven by belt and some directly connected, with a switchboard on which all makes of instruments are discernible—a station which has grown up with experience of a costly interest-devouring nature, a concrete history of the development of the art, so frequently found here, the despair of the manager and the haunting bete noire of sundry shareholders—one finds a perfect whole, carefully designed and executed with thoroughness. One is not confronted with the "Oh, it'll do" earmarks of expediency. It is usually a consistent installation throughout. Indeed, there are but few stations in America which can compare in finish of detail, symmetry, and general perfection with some of the recent installations which I had the pleasure of seeing in England and France. It should be remembered, however, that both these countries have profited largely by our experience, and perhaps I may be giving them too much credit for avoiding the rocks and shoals which we encountered in our pioneer work. We have the apparatus, but do not seem to dwell largely enough upon the necessity of absolute thoroughness throughout the station. At the stations of Croydon, near London, and Versailles, near Paris, the cleanliness, neatness, and general consistency is noteworthy, and yet in each of these stations apparatus of American make alone is used.



Synchromizing Circuits.

One striking difference between English and American practice lies in the willingness with which the manager of an English station will give another valuable information regarding his experiences with his own plant. Here, our managers, outside the Edison fold, are as silent as carp regarding their methods of management, economies induced, and results achieved. They are "giving away no wrinkles" to the other fellow. He might some day become a competitor. He never does; but silence is golden, and thus much useful knowledge is withheld.

As I said before, electric lighting is still a luxury. This remark applies more strongly to the use of the current in houses and stores. Street-lighting by electricity is becoming very general in both countries, and both London and Paris have now very creditable services. During the past two or three years the incandescent lamp has had an arduous struggle against the mantle gas burner, the application of which did not necessitate the cost of a wiring installation, but it affords me pleasure to say that this light has been found so trying that it is rapidly dwindling in popularity. This assurance has been given me by lighting-station managers who have felt the competition. In France, where the gas companies are more powerful, the mantle gas burner is still a very active competitor. An excellent indication of the increasing use of electricity for lighting purposes lies in the fact that the manufacturers of gas fixtures are now turning out large quantities of fixtures wired for incandescent lamps. Such an increase can only have had one cause—the increased use of current.

The business in electrical appliances and supplies is healthy in tone, and manufacturers are crowded with orders. English and French appliances are, as a rule, made with a little less utilitarian aspect than are ours. Their snap switches, fuseholders, cut-outs, etc., are not so homely. There exists a desire to render them artistic, and they can thus be used in places where our rosettes, cut-outs, etc., would need boxes to hide them in. American manufacturers of lighting supplies, before entering into competition with English manufacturers, would perhaps do well to study carefully the character of the demand before attempting to press upon the market the appliances which are accepted here. I noticed in many stations that American measuring and indicating instruments, as well as recording watt-meters, were used. To my enquiries I received replies very flattering to the manfacturers.

The most marked advance electrically made during the last two years in England and France is in the railway field. The urgent demand is for an improved method of traction, and both countries are in a position similar to that in which this country found itself in the early nineties. The improved method must be electric. Cable traction is now considered out of date so far as rapid transit is concerned. Compressed-air traction is the laughing stock of all street railway engineers and managers. Compressed air has been played upon the Transatlantic public altogether too often, and mention of the compressed-air car experiments in New York, in the presence of English, French, or German engineers, usually provokes a smile of pity for those furnishing the money for the experiments. They have long ago passed that point in Europe.

Electric traction is therefore the order of the day. The success of the trolley roads in Bristol, Birmingham, Dublin, Coventry, Lyons, Marseilles, Havre, and those in Germany is the common incentive to reform elsewhere, and the change is sure to come, and quickly. The mnuicipal authorities of Glasgow and Liverpool have practically decided upon the use of electricity in lieu of horses.

The field for electrical traction in England and France is large, but it should be borne in mind that in England at least a large number of the tramway companies' charters carry the municipal purchasing clauses, and that committees and not individuals will have to be dealt with. Furthermore, electric railway apparatus cannot be sold upon "wind." Neither Englishmen nor Frenchmen will purchase apparatus on the mere ipse dixit of an American manufacturer, and in both countries guarantees have an unpleasant knack of being enforced by the courts. If American apparatus is to make its way in England and France it must emerge successfully from the tests which will be applied to it, and manufacturers must be prepared to find the guarantee severe in its conditions, and it will not be possible easily to buy the cancellation of the guarantee.

Pole Line in Butte Canyon.

One thing more: Americans should realize that they have to live down considerable odium caused by the super-smartness of certain of their compatriots in former days. The English and French have been gulled on many occasions, and to term a device American implies with them a quality of second-rateness extremely galling to the sensitive American. Bearing this in mind, the American manufacturer should be able to sell goods in England. He has no tariff to act as a deterrent, and provided his products are up to the standard, success should meet his efforts.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity, Gas and Power.

OFFICIAL ORGAN OF THE PACIFIC COAST
ELECTRIC TRANSMISSION ASSOCIATION.

SUBSCRIPTION PAYABLE IN ADVANCE. TERMS—DOMESTIC, ONE DOLLAR
PER YEAR; FOREIGN, TWO DOLLARS PER YEAR.
RATES FOR ADVERTISING ARE MODERATE.

The trade supplied by the San Francisco News Company.

EDITED AND PUBLISHED BY GEO. P. LOW.

Business Office, 516 COMMERCIAL ST.
Telephone, Main 1145.

Address all communications to
Editorial Rooms, 427 TENTH AVE

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME V. OCTOBER, 1897. NUMBER 1

EDITORIAL.

THE BLUE LAKES PLANT.

Whoever it was that compared humanity to a flock of sheep, blindly following the leader, made a cap that sometimes fits even engineers, and an evidence of it may be found in more than one branch of science. The erection of very high poles in transmission work "to reduce loss from earth induction"—that vague, undefined something-or-other that none comprehend—involves electrical engineering, and the use of receivers in pipe lines—that aping of the steam practice which finds a storage reservoir in the drum of a boiler—involves hydraulic engineering; while it is probable that no branch can stand acquitted of the charge that it is not in one way or another, blindly persisting in following a certain course of procedure, simply because others have gone that way before.

The Blue Lakes plant is deserving of marked distinction, if for nothing else than for the boldness with which it has departed from several well beaten and circuitous engineering paths, and the directions of these paths are indicated in the leading article of this number. Particularly are innovations introduced in the hydraulic equipment, for there is to be found at Blue Lakes City a pipe line over thirty-two hundred feet in length, delivering water at a head of over a thousand feet, which is absolutely without either air vent, relief valve, air chamber, or receiver of any kind. There are hydraulic engineers the world over who would stand aghast at the mere suggestion of building such a pipe line and who would ask in ridicule, "who ever heard of such a thing," overlooking the fact that new things are heard of daily.

The ideas which have prevailed in the construction of the Blue Lakes pipe line have been to accomplish a single direction of flow and an easy acceleration of the water, coupled with a high factor of safety, absolute rigidity and slow moving valves in the pipe line. The pipe tapers in diameter by easy graduations, and the acceleration of the water increases by correspondingly easy stages until the "Y" castings are reached, when the speed grows more rapid until a spouting velocity of about three miles a minute is attained, and nowhere do sudden changes occur either in its speed or direction. The main valves can not be closed in less than ten minutes, which prevents the possibility of water ram, and should a break occur, draining the pipe line, and subjecting it to atmospheric shock, the substantial manner in which it is buried, the lower portion being in solid concrete throughout, will support it, so that in rendering flattening impossible, it will prevent collapse.

The further innovation of mounting water and fly wheels on overhanging bearings is too fully discussed elsewhere to require further treatment here, but the perfect satisfaction that has thus far attended the operation of the plant practically confirms the correctness of its engineering design, and without doubt the radical departures there introduced will prove of epoch-marking significance in the annals of hydraulic engineering.

WHERE THEORY FAILED.

When the New York, New Haven & Hartford Railway Co. first took up the third rail conductor system to replace the overhead trolley, the electrician in charge consulted a large number of electricians with varying results; most of these experts said there would be an enormous waste of current by leakage from the third rail, which has a potential of 600 volts. The system was tried, however, and acording to the American Engineer, Car Builder and Railroad Journal, actual tests gave the following results:

The line consisted of seven miles of third-rail conductor, a return through the T-head service rails, two miles of copper cable from the power house to the track, with all joints copper bonded. At the first test trouble was experienced from leakage. The test was made after a storm, while the ground was wet and conditions very unfavorable, and a leakage of 2.6 amperes was discovered. It was afterward found that the truckmen had driven a spike through the white metal cable covering, and thus destroyed the insulation. The wires were found melted through, amounting to one-third the section of the cable. The second test was made on a dry evening with favorable conditions, and a circuit leakage of 0.5 amperes was found. The third test was made while the track was flooded with water for a distance of about two miles, though the motor cars continued their regular trips and no inconvenience was experienced at the station. A trolley street line took its current from the end of the third-rail conductor, and continued at its regular speed notwithstanding the fact that the third-rail was connected with the return circuit through the service rail by a water bond.

The fact is that the conductors are so large and their resistance is so small that there is no inducement for the current to leave the rail for a poorer conductor.

CENTRALIZING RAILWAY POWER STATIONS.

The Electrical Engineer (N. Y.) for October 7th describes, with detailed plans, the new 70,000 horse-power central station to be erected by the Metropolitan Street Railway Company in New York City, on a site close to the river front bounded by Ninety-fifth and Ninety-sixth streets and First avenue. Aside from its magnitude it will be one of the most noteworthy installations ever erected and for boldness of design the plant must stand as monumental in engineering annals.

The building will rest on a foundation of 8,000 piles covering the whole site, which measures 201 feet by 270 feet. Its coal storage bins will have a capacity of 9,000 tons and, being located at the top of the boiler house, will render the handling of coal by conveyors, a very simple matter. Eighty-seven water tube boilers, grouped in nests of two each, and each boiler having a nominal capacity of 500 horse-power and capable of being forced to 800 horse-power, will be installed. Provision will be made for forced draft and the chimney will be not less than 350 feet in height with an inside diameter of 22 feet. The engine equipment will consist of eleven vertical, cross compound, condensing engines—each having a nominal capacity of 4,000 horse-power, with a maximum capacity of 6,600 horse-power, and each of which will be direct connected to a three-phase generator, delivering current at a potential of 6,000 volts. The current from these generators will be conveyed under-ground to sub-stations located at proper points on the lines of railway to be supplied, and in which static transformers in connection with rotary transformers will convert the current to a pressure of 550 volts, direct current, to be utilized in the conductors of the conduit of the under-ground electric railway system, with which it is designed to supplant all horse, cable and overhead trolley railway lines existing in the city.

The woful inefficiency of operating a street railway system from several power houses located in various portions of a city and entailing increased operating expenses in the way of coal haulage, running non-condensing and using small units, together with vastly multiplying the cost of real estate, equipment and attendance, has long been appreciated, but heretofore no plant of note has combined its entire power plant under one roof, and coupled with that power plant the most modern methods for the transmission of power. It certainly seems that the credit for demonstrating the feasibility of the idea is due to the success which has attended the operation of street railway lines from power transmission circuits as is done in Portland and Sacramento, and further refinements in the system may probably be looked for in the adoption of storage batteries in the sub-stations. With these installed, the plan projected by the Metropolitan Street Railway Company would be ideal.

Without doubt, other street railway systems have planned the ultimate adoption of a similar installation, and among these cities San Francisco may be enumerated. What, let it be asked, in the light of present engineering practices, is more wasteful and extravagant than the continuing in use of separate steam plants for the operation of the cable lines of the Powell, Geary, McAllister, Market and Valencia Streets and Howard Street railway systems, when they could all be operated by motors supplied with current at high potential from polyphase generators placed in the Bryant Street power house?

IT WILL BE WELCOMED.

For some time past there has been noted a growing tendency on the part of the principal manufacturing companies represented on the Pacific Coast to favor the organization of a construction company that would embody the requisites of independence, engineering ability and financial standing. This conclusion seems to be the natural result of the conviction that the manufacturing of machinery forms an industry quite foreign to that of its installation, and while heretofore, and even at the present time, most manufacturing concerns adhere to the plan of erecting their own products, it must be said that almost without exception they have been forced into the construction business by existing circumstances, even though such action has been against their judgments. The installation of their plants is by no means a voluntary undertaking on the part of the great companies. In stating the truth that as a rule the construction departments of manufacturing concerns have generally been run at a loss, one should add the equal verity that the manufacturing industry is ready to welcome the relief that a well organized construction company would afford from the annoying and unprofitable details attending the erection of their machinery.

It is understood that such a construction company has practically perfected its organization and that the new concern will be representative not only of the leading electrical manufacturing companies, but also of recognized engineering ability, as well as of some of the most substantial financial interests of the West.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

COMPUTING THE GIRARD GOVERNOR.

In the issue of August last was given a description of the dynamometer governor used with the Girard water wheels at Bakersfield, Cal., in which it has been found that the mathematical solution then given is not correct.

Beginning at the last paragraph at the bottom of page 89, the matter should read as follows:

Let the distance from the center of the pin V to the pin attaching link L to lever E be 13¼ inches. Then we have $\frac{1313 \div 6''}{13\ 25}$=594.5 lbs. as being net force which we must have acting radially outward from the above mentioned central point in order that full power may be transmitted through the dynamometer, to which must be added the effect of the other component of the forces acting at the pin H, which is equal to $\frac{75s\ \text{lbs.} \div 3.76}{13.25}$=215 lbs., and there must also be added the total initial tension of the two springs S and S, which, let us assume as 305.5 lbs. Then the total centrifugal force of all the elements swinging about the point H must be such that, when assumed as concentrated at the central point above mentioned between the springs S and S', it shall just equal 594.5 lbs. plus 215 lbs. plus 305.5 lbs., or 1115 lbs., and the central point will then be traveling, let us say in a circle 24⅛ inches in diameter and all parts will be in the position shown in the sketch. Considering now the conditions when the swing levers are thrown to their extreme outward position by centrifugal force, the central point above mentioned will travel, let us say, in a circle of 13 15-16 inches radius, then a weighted swing lever which produced 1115 lbs. centrifugal effect in the first case, will now at the same number of revolutions per minute, cause a centrifugal force of 1290 lbs., and the springs S and S' will each be increased in length 3¾ inches.

The springs S and S' must be of such proportions that when having a fixed load of 305½ lbs., an additional load of 984½ lbs. will cause them to be extended 3¾ inches.

Under these conditions the conclusions set forth in the article referred to, prevail.

INSURANCE RESTRICTIONS ON ACETYLENE

That the insurance fraternity of our cousins across the line do not look favorably upon the use of acetylene for purposes of domestic illumination seems evident from the following regulations which have been issued concerning acetylene gas by the Canadian Fire Underwriters' Association and which are reproduced from the Canadian Engineer:

First—That no calcium carbide or gas generating machine be allowed in any building insured.

Second—That generator must be placed in a separate building, constructed as follows, viz.:—Walls solid brick or stone not less than nine inches thick; roof entirely of iron or other fire-proof material; floor of cement or concrete with slight upward slope from door; entrance to be an iron or standard fire-proof door, no windows or other openings except for ventilation, which shall be through an iron pipe not less than six inches in diameter protected sufficiently through the roof and turned down at the outlet. Genators must be provided with escape pipes of sufficient capacity to allow gas to escape freely at a pressure not exceeding five inches of water. Care must be taken to deposit residue from generator at a safe distance from any building.

Third—That generator building must be located at least ten feet from a brick or stone building, or twenty feet from one of any other construction.

Fourth—That the storage of calcium carbide be limited to three hundred pounds, to be kept in air-tight metallic cases not exceeding one hundred pounds capacity, and confined to the generator building.

Fifth—That if the above regulations are not fully observed, double rates must be charged.

DETERMINING METER RATES—A CORRECTION.

The omission of a cipher, through typographical error, in the second factor of the divisor of the formula given on page 121 of the last issue, makes a correction necessary.

The formula should have read:

$$\frac{C}{\frac{746}{p} \times \frac{h}{1000}} = c$$

Where C = Cents per horse power per year, flat rate.
p = Power factor of motor.
h = Working hours of motor per year forming basis of flat rate C.
c = Cents per kilowatt hour.

In this connection it is well to add that the measuring instrument is to be inserted in the circuit between the transformer and the motor, thus making the power company stand the transformer loss and the consumer stand the motor loss. If it were not so, the factor "p" would be omitted from the formula.

METERS FOR ELECTRIC CARS.

There is considerable merit in the suggestions contained in the paper read by Mr. Caryl D. Haskins on "The Influence of Accurate Measurements upon Economic Operation" before the New York Street Railway Association and which, after describing the development of total output meters (standard designs of which exist up to 8,000 amperes with special designs up to 16,000 amperes and which give a true energy account on loads ranging from 5 per cent to 6 per cent of their rated capacity upto 15 per cent above their rated capacity), advocated the placing of a meter on each car of an electric railway system for the measurement of the energy used daily in its operation.

"Every street railway management realizes," contends Mr. Haskins, "that quite a large proportion of the total energy generated is wasted by the careless and improper use of the controller and the brake, and where the old rheostat method of control is used the opportunity for waste on the part of the motorman is yet greater. Almost every street railway superintendent, moreover, makes a different estimate of the percentage of power wasted upon the system under his charge, for there can be no positive knowledge upon the subject nor can the conditions be regarded as at all stable. An average drawn from the opinions which have been expressed to me, would, however, indicate that no less than 20 per cent of the total energy generated is wasted by improper manipulation of the handles upon the part of the motorman. This improper manipulation being due, to some extent, to ignorance, but more generally to carelessness."

The practice which was long since adopted by many steam roads of offering prizes to the engine crew doing the most work with the least coal and water, could well be patterned after by street railway companies, which will find the adoption of meters on electric cars to afford a reliable means of checking the carelessness of motormen and of reducing the amount of the coal and water bill. This means either a saving of say 10 per cent in the operating expenses or the ability to operate 10 per cent more cars with the same central station capacity.

"Them electrical fellers is goin' ter make us work fer 'em," bubbled the Water Fall to the Brook.

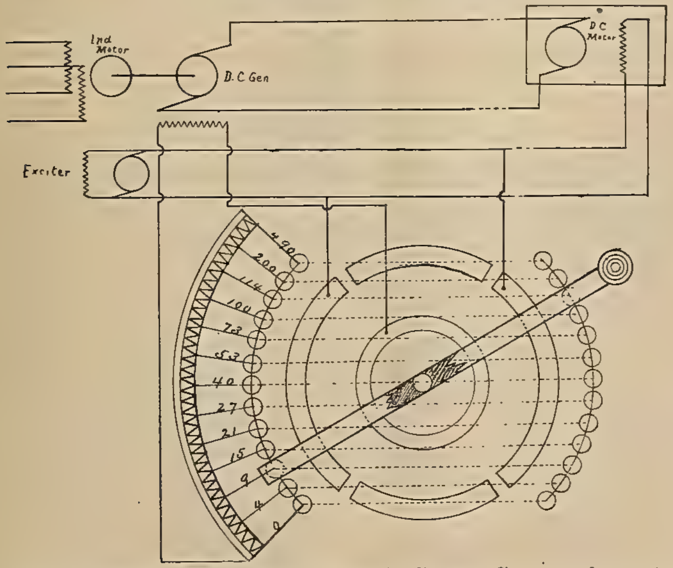
"Well, I'll be dammed!" babbled the Brook.

—Electrical Review, N. Y.

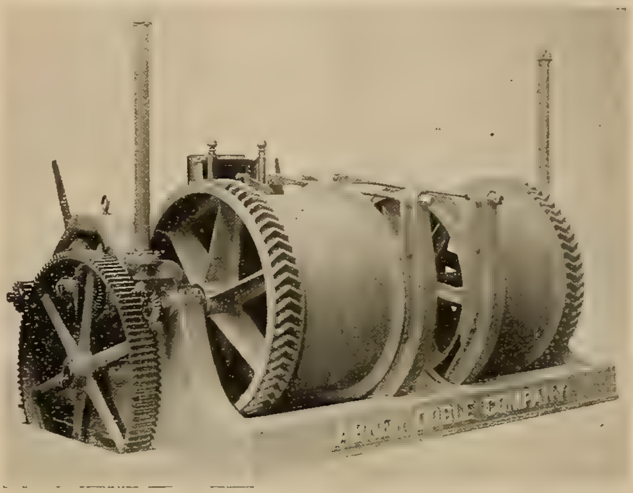
Mining

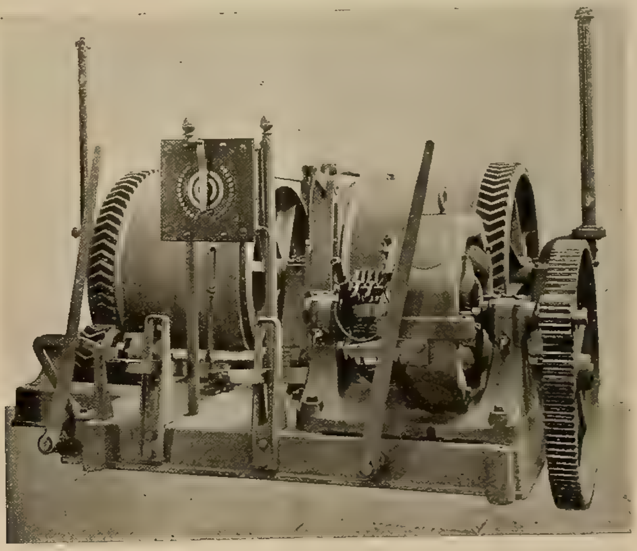
A SUCCESSFUL TWO DRUM ELECTRIC HOIST.

Various expedients have been resorted to in California for the operation of mining hoists by electric power derived from polyphase circuits. Induction motors are in satisfactory use in two single compartment shafts in mines in Shasta County, the motor being geared direct through an engaging clutch to a winding drum in ascending, and lowering being accomplished by an ordinary band brake. Shafts containing two or more compartments, however, present diffculties not found in single compartment shafts, particularly for the reason that it is desirable to use a single motor for the operation of all compartments, for the reason that the skips can be balanced one by the other. The two compartment hoist in the Gottschalk mine, which is one of the Calaveras properties of the California Exploration Company, is operated by a combination two-phase and direct current system embodying new features not heretofore seen on the Pacific Coast.



A twenty horse-power General Electric two-phase induction motor is direct connected to a 15-kilowatt, direct current multipolar generator, having 125-volt fields and a 500-volt armature and from the shaft of which is belted a one-kilowatt 125-volt shunt wound, bi-polar exciter. The equipment thus far described, together with the necessary step-down transformers, is placed in a small sub-station at the entrance of the mine tunnel, and within the mine is a 20- horse-power, multipolar, direct current motor, having fields and armature corresponding to those of the generator, and which is geared through a double reduction to a two-drum hoist as shown in the accompanying illustrations. Conveniently located on the hoist is a controlling field regulator by means of which, as will be detailed, perfect control of the skips is had.





The circuit connections of the equipment appear in the accompanying outline diagram, in which the field regulator is shown in exaggerated size that its construction may be more fully understood. From this diagram it is clear that the shunt wound exciter maintains a constant excitation of the fields of the motor and that from it is also derived current for the excitation of the fields of the direct current generator, such current being of either polarity as required and of a wide range of amperage due to the introduction of a graduated resistence into the exciting current. The value of this resistance in ohms is expressed on the diagram.

Inasmuch as the fields of the motor are under constant excitation at a fixed polarity and as the armature of the generator is permanently connected with that of the hoist, and as, moreover, the generator is normally running with no field, it is evident that the creation of any field in the generator will be instantly manifested in the armature of the hoisting motor and also that the direction of rotation of the motor armature will depend upon the polarity of excitation of the generator fields. These conditions are effected with the utmost celerity by the simple manipulation of the reversing field regulator, which is, as stated, merely a pole changing and resistance device controlling the generator fields. The motor gearing engages with either drum at will and the usual mechanical band breaks are provided to hold the skip at any level and in lowering. The hoist has a capacity of raising 2,000 pounds net, at a speed of 200 feet per minute. Whatever may be said of the first cost, complication or efficiency of the Gottschalk hoist, it is certain that in matters of ease of control and reliability of operation, it stands pre-eminently superior to any polyphase driven two-drum hoist yet installed in the far West.

The form of hoist equipment described constitutes that known as the H. Ward Leonard system and it was built and installed by the Abner Doble Company, San Francisco, all direct current apparatus being of Crocker-Wheeler manufacture.

Personal

Mr. A. E. Brooke Ridley is now in the East on business and may go on to London before returning.

Mr. J. A. Cranston, of the Portland office of the General Electric Company, has been a welcome visitor in San Francisco recently.

Mr. J. W. Brooks, of the Brooks-Follis Electric Corporation, has returned to San Francisco after a month spent in the various business centers of the East.

Mr. George B. Fraley, who was prominent in electrical circles of San Francisco three or four years ago, is now manager of the Globe Electric Heating Corporation, of Philadelphia.

Mr. Donald H. Fry, of Stanford's '96 class in electrical engineering, and more recently of the Union Iron Works, is now connected with the Blue Lakes Water Company's electric power plant at Blue Lakes City, Cal.

Mr. L. B. Pemberton has relinquished the Southern California agency of the General Electric Company at Los Angeles and is now editing and publishing "Town Talk," a very entertaining society paper of Pasadena, Cal.

Mr. C. E. Dutcher, who bears the reputation of being one of the most thorough constructing electrical engineers of the Pacific Coast, is at present engaged in expert work for the Doris Syndicate, Ltd., of London, Eng., at Candelaria, Nev.

Mr. F. W. Hawley, of New York, one of the electrical engineers associated in the construction of the Niagara Falls electric power plant and prominently identified with the recent electrical exposition in New York City, is, it is said, under engagement by Mr. C. P. Huntington to report on the cost and advisability of equipping the local steam lines now connecting with the ferry system at Oakland Mole, with electric traction.

Mr. C. S. Young, of San Francisco, well and favorably known in financial and mining circles throughout California and Nevada, and late right-ofway agent for the San Francisco and San Joaquin Valley Railroad, will soon enter the business of promoting and financiering electrical, transmission and similar undertakings. His reputation is of the best and any enterprise he enters will be assured of the strongest financial support.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

NEW AGENCIES FOR THE COAST.

Mr. John W. Brooks, who has just returned from an extensive trip throughout the East, in the interest of the Brooks-Follis Electric Corporation, of which he is the manager, has brought out a number of new lines of material that will be interesting to all in the electrical business.

Their contract with the Interior Conduit & Insulation Company, of New York, manufacturers of the well- known Lundell Fan and Power Motors, has been renewed. In this connection, it will be well to state that the Interior Conduit & Insulation Company have consolidated with the Sprague Electric Company, manufacturers of electric elevators, and are going to build machines direct connected and belted up to 150 kilowatt.

The Brooks-Follis Electric Corporation will carry machines in stock as high as 50 horse-power, so will be in an enviable position to fill orders for machinery of this kind with promptness and dispatch. The price on Lundell Fan Motors has been reduced for the coming year, and they anticipate a large business in this line.

They also concluded arrangements with the Herzog Teleseme Company to handle their well-known line of signal apparatus for hotels and elevators. The Herzog Teleseme Company is manufacturing a small annunciator of 10 drops capacity, which does not occupy more than 3x7 inches. This is quite a novelty in its line, as it is the first annunciator that is impossible to get out of order. They will make them for all sizes, and the price is extremely low.

Another novelty that they have brought out from the East is Electric Signs that can be used both in the day and night time. This sign is made up similar to all signs for day use, and has raised gold letters on it, thus making it a show sign for day use. It has small holes distributed throughout each letter, which are filled in with opalescent glasses. Incandescent lamps are arranged so as to give a proper distribution of light, thus making it a perfect electric sign, and by far the best thing yet on the market. One special point of advantage in this sign is the economy, as it only requires one-fifth of the number of incandescent lamps required to operate the ordinary electric sign, and furthermore, it can be used both day and night. It is fully covered by patents, and they have absolute control of the entire Coast.

The Anchor Electric Company's specialties of sockets, snap switches and push button switches are also handled by them. These switches are too well-known to require any comment, and they expect to do a large business in this line.

They have also brought out a full line of A. T. Thompson's electrical material for electric photographing, stereoptican and optical work, as well as a full line of slides for same.

Fisher & Cramphorn's line of knife switches are also well-known, and the Brooks-Follis Electric Corporation has the Coast agency.

They are putting on the market a very neat thing in the way of electrical medical battery. It is neat and compact in size, and is handsomely finished in Spanish cedar.

Among other lines of material carried by this well-known firm may be mentioned the Duncan Arc Lamp, Crescent Wire, manufactured by John A. Roeblings' Sons Co., Raven White Core and Grimshaw Wire, and Grimshaw and Competition Tape manufactured by the New York Insulated Wire Company, and also the telephone apparatus manufactured by the Standard Telephone & Electric Co., for whom they are the Coast agents.

The telephone apparatus is meeting with marked approval and over 9,000 of these instruments are in use in the State of California alone. In the city of San Jose there is an installation of

800 telephones, and only one man is required to chase trouble on the line. It would pay anybody to communicate with them who contemplates the installation of a central station or of small intercommunicating sets. A full stock of this material is carried in San Francisco.

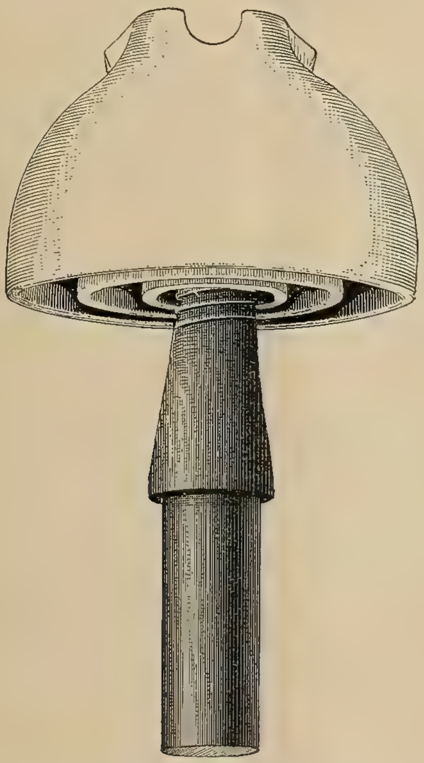
While East, Mr. Brooks made arrangements to place the Eastern agency for the Duncan Arc Lamp.

The lamp is extraordinary in its line, requiring only 2¼ amperes of current burning at 100 volts to operate the lamp, on either direct or alternating current, and it gives 750 candle power. It burns 100 hours without retrimming, and while it is economical in the cost of current consumption, it is economical in the cost of carbon consumption, as it requires only $1.08 worth of carbons per year per lamp.

Mr. Brooks reports trade in the East as being very brisk, and say the outlook for next year is very good.

IMPERIAL PORCELAIN INSULATORS.

C. S. Knowles, of 7 Arch street, Boston, and who is general agent for the Imperial Porcelain Works, of Trenton, N. J., has issued an attractive little booklet which embodies much that was contained in the paper read by Mr. H. D. Sears before the Santa Cruz Convention of the Pacific Coast Electric Transmission Association (see Vol. IV, No. 6, page 117) and which also describes the special features of merit of the Imperial High Potential Porcelain Insulators, now being used on the Niagara-Buffalo transmission line, and which are to be used on the 33,000-volt circuit of the Southern California Power Company.



The claim is boldly made that the problem of securing a high potential insulator has been solved in the use of Imperial Porcelain, in support of which the assertion is made that wherever high potential insulators have proven satisfactory they have been made of Imperial Porcelain. Wherever they have given trouble they have been of other makes.

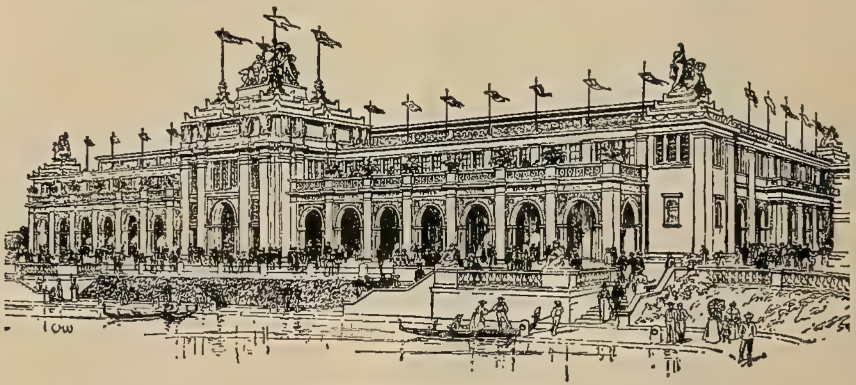
In support of this statement, the "Electrical Engineer" of December 23, 1896, is quoted, which states that: "Reports from Niagara go to show that the power tranmission to Buffalo is working very successfully. The trouble with the insulators has been eliminated since the exclusive use on the line of the 'Niagara' insulators made by the Imperial Porcelain Works."

There is also added a letter from Paul M. Lincoln, electrical superintendent of the Niagara Falls Power Company, dated January 21, last, in which he says: "The insulators which you have sent us and which have passed our test are satisfactory in every respect. We have yet to have our first trouble with them on the line. This applies to the 'Imperial' type as well as to the larger sized insulators which we are using, although the 'Imperial' type insulators were put up for only temporary use. The quality of the porcelain is much better than any other that has come under my observation. It is thoroughly vitrified and homogeneous throughout."

Continuing, the circular states: As our smallest insulators will stand the puncture test as well as the largest, the style to be used in any case is decided by the surface distance and the direct distance between tie wire and pin. The greater these distances the less liability there is to surface leakage and to the current jumping through the air. The higher the voltage used the larger, of course, should the insulators be. It is rather difficult to give the exact voltages to which our different types are adapted, as the climatic conditions have to be carefully considered. The following, however, we consider safe under all except extremely unfavorable conditions:

Imperial Nos. 3 and 4 for 5,000 volts; Imperial No. 2 for 10,000 volts; Imperial No. 1 for 15,000 volts; Redlands, type C and Niagara for higher voltages. In most cases, however, we should not hesitate to recommend Imperial No. 2 for 15,000 volts and Imperial No. 1 for 20,000 volts."

All types of Imperial insulators are "triple petticoat," and all, except "Niagara," are circular in shape. We would call special attention to this type; it is oval in shape and has a gutter on each side for the purpose of draining water clear of the cross-arm. Imperial No. 3 is made with a large top groove and was designed specially for carrying electric railway feeder cables. In vertical cross section all types are of the same general design.



The Electricity Building.

Messrs. Jonn A. Roebling's Sons Co., 25-27 Fremont street, San Francisco, are Pacific Coast agents for Imperial Porcelain Insulators.

ELECTRICITY AT THE TRANS-MISSISSIPPI EXPOSITION.

Electricty will play a very prominent part in the Trans-Mississippi and International Exposition, to be held in Omaha, Neb., from June to November, 1898, as is evident from the plans and preparations that are being made for the erection of the machinery and electricity building. This structure is located in the northeast corner of the Grand Court, being east of the Mines building and across the lagoon from the Manufacturers building. The design is goverened by the general conditions requiring harmony with the other buildings; the architecture of the group is modern Renaissance.

The building is 304 feet front by 144 feet in depth. There are triple entrances on the main floor level in the center of the main front, and similar groups in the centers of the east and west fronts, with four emergency exits in the north wall. In front of the building, flanking both sides of the main entrance, is an open portico sixteen feet wide, running the entire front of the building. The center entrance feature projects beyond the portico, thus forming the grand entrance vestibule. The main floor covers the entire area of the building. Above is a gallery thirty-two feet in width, extending around the four outer walls. The gallery is reached by spacious staircases located in the front corners of the building. In the rear corners are commodious toilet rooms. This leaves a high central court 248 feet long by 80 feet wide, lighted from the sky-lights and clere-story windows above the roof.

The character of the exhibits sheltered by this building is shown by the decoration. The ornamental spandrels and panels receive all of their motifs and suggestions from machinery. The cresting at the top is composed of cogwheels, this principle being carried out in all of the decorations. The underlying principle and function of machinery is symbolized by the groups of statuary on the top of the building. At each of the four corners are groups representing the early supremacy of man over the untamed forces of nature. These forces are represented by wild animals. Men in their youth are seen subduing them for the simple purpose of escaping injury and the preservation of their own lives at the sacrifice of the natural forces. A higher supremacy is shown by the center group, which is the dominating feature of the entire design. In this, man developed beyond the youthful stage, having wisdom, takes these same untamed, unharnessed forces of nature and harnesses them to his chariot, making them do his bidding, symbolizing in a direct way the service which machinery does for man in using the powers of steam, fire, electricity and graviey.

Color enters into the design with maximum importance. The ornaments in the panels under the porticos and over the main entrances will be highly emphasized by small background spaces of strong colors. These are treated in such a way as to give great interest to the spectator near by without detracting from the general quiet and dignity of the view from a distance. The entire building will be a series of yellow and ivory tones, growing more intense as they reach the top, culminating in the dull golden statuary full of primitive vigor which surmounts the building and symbolizes its use.

BUILDERS OF THE BLUE LAKES PLANT.

Whenever an enterprise of magnitude is completed and put in operation, the engineering public becomes at once desirous of learning who were the builders of the enterprise or, in other words, to whose care was intrusted the furnishing of the labor, materials, and apparatus that constitute the vital portions of the plant. The answer to this enquiry, if relative to the electric transmission plant of the Blue Lakes Water Company, will now be given.

The copper for both the transmission circuits from the plant was furnished by the San Francisco branch of the John A. Roebling's Sons Company, and the wire is supported on Locke's triple petticoat China insulators, furnished by John Martin, Pacific Coast agent for Fred M. Locke, of Victor, N. Y.

The redwood poles of both the Amador and Calaveras circuits were supplied by the Union Lumber Company, of 106 California street, San Francisco, who make a specialty of selected redwood poles in all sizes and lots.

The entire electrical equipment, including generators, switchboard and transformers, was furnished by John Martin, of 300 California street, San Francisco, Pacific Coast agent for the Stanley Electric Maunfacturing Company of Pittsfield, Mass.

The electrical installation was placed under the direction of Theodore E. Theberath, electrical engineer for Mr. Martin.

The Abner Doble Company designed, built and installed the Doble water wheels used in the plant and also furnished the exciters, the steel "Y" castings and slip joint steel pipe used in the upper portion of the pipe line.

The lap-welded steel pipe used in the lower portion of the pipe line was made by the National Tube Works and furnished by the Dunham, Carrigan & Hayden Company, Pacific Coast agents, while the rivited steel pipe was furnished by W. W. Montague & Co., San Francisco.

TABLE OF CONTENTS.

VOLUME V, NUMBER 1.

Illustrated articles are indicated by an asterisk (*)

Transmission

Page.

*A SIERRAN TRANSMISSION, by Geo. P. Low.
Part I.—The Water Supply 1
Part II.—The Canal System 3
Part III.—The Pipe Line 4
Part IV.—The Power House 6
Part V.—The Hydraulic Plant 7
Part VI.—The Electric Plant 9
Part VII.—The Amador Circuit 12
Part VIII.—The Calaveras Circuit 14
Part IX.—Financial 16
Part X.—Personal 17

Editorial

Centralizing Railway Power Stations 23
It will be Welcomed 23
The Blue Lakes Plant 22
Where Theory Failed 22

Passing Comment

Computing the Girard Governor 24
Determining Meter Rates 24
Insurance Restrictions on Acetylene 24
Meters for Electric Cars 24

Gas

The Explosiveness of Acetylene 17

Illumination

European and American Practices, by J. McGhie 18

Mining

*A Successful Mine Hoist 25

Authors

Low, Geo. P. 1
McGhie, J. 18

Personal

Brooks, J. W. 26
Cranston, J. A. 26
Dutcher, C. E. 26
Fraley, Geo. B. 26
Fry, Donald H. 26
Hawley, F. W. 26
Pemberton, L. B. 26
Ridley, A. E. Brooke 26
Young, C. S. 26

Industrial

Builders of the Blue Lakes Plant 28
*Imperial Porcelain Insulators 27
*Electricity at the Trans-Mississippi Exposition 27
New Agencies for the Coast 26

The Journal of Electricity

VOL. V. NOVEMBER, 1897. No. 2

Hydraulic Problems[*]

BY W. STUART SMITH.

THE first difficulty which confronts a would-be promoter, in attempting to develop a cheap power supply, is likely to be an hydraulic one, and as such supply generally has its origin in a water power, the discovery of which is by no means easy when it is coupled with the desideratum that, when developed, some use must be found for the power if the company is to be kept from going through a process of liquidation in consequence of its assets being mainly water.

A suitable water supply having been found the details of its development will depend upon the conditions, such as minimum volume of flow for ordinary seasons; whether the location is such as to insure an annual precipitation sufficient to maintain, at low water seasons, ample supply for the development of the requisite power; whether the power is required for 24-hour service, etc. These conditions will determine whether expensive impounding dams will be required or only cheap wing dams for deflecting the water into ditches or flumes. The building of the dams will generally present no difficulties that cannot be foreseen, though each case will offer its own problems for solution. The cheap production of structural steel in these days will be certain to result in its use in many cases with probably cheapened cost of construction.

Such improvements as are necessary at the initial source of supply having been completed, the next consideration is the means for conveying the water to the point where power is to be developed. For this, two plans present themselves, one employing an all-closed conduit such as a pipe, for the entire distance, and the other making use of an open conduit to a point as near as possible to the power house, the remaining distance being bridged by a pipe by means of which the water may be conveyed with but little loss of head. In connection with the first or all-closed conduit, method, the hydraulic problem presents two opposing factors, each of importance. In favor of the method is the fact that of the head which would be lost in an open conduit, the greater portion could be saved with a pipe, and in case the final head is moderate this saved portion might become of very great importance. The opposing factor is the fact that all such strains as result from the movement of the water are very greatly increased with increasing length of pipe.

Generally the determining factor in the conduit problem is a commercial one, the cost of an all-closed conduit being much greater than that of an open conduit of the same capacity. If the head lost in an open conduit is not a very great consideration, this will generally be adopted and it may take the form of a ditch or flume as circumstances may dictate. Physical conditions frequently determine whether ditch or flume be used since in many cases a ditch is practically an impossibility. The question is frequently asked whether ditch or flume is best but to this query no general answer can be given even when the physical conditions are equally favorable to the construction of either, as other considerations than cost of construction and maintenance may govern. If water is to be had in ample quantity so that saving it does not have to be considered a ditch may frequently be preferable, but with a ditch of great length the loss of water may be enormous and is always an indeterminate quantity. Seepage through the soil occurs everywhere and large quantities will follow unsuspected clefts in rock formations, often appearing as never-failing springs far away from the ditch, also such leakage points may develop where they did not previously exist and great waste may be going on where none is suspected. Careful measurements of the volume of water flowing will show extraordinary leaks to exist between certain limits but exact location and stoppage will necessitate shutting down the plant—a very undesirable thing to do. When the water supply is such that storage reservoirs are required to tide over seasons of small precipitation, such waste cannot be tolerated and the use of a flume may be imperative regardless of cost since this construction permits of easy inspection and, except in case of very serious breaks, repairs can generally be made without shutting off the water. There is the further consideration that the scouring action of the flowing and swirling water is absent.

The magnitude of the proposed installation and the effective head on the wheels will determine the advisability or necessity of putting in one or more pipe lines between power house and terminus of the open waterway. If the head is low and the volume of water consequently great, the development of any considerable amount of power will make the use of more than one pipe imperative, but with the very high heads found in many places on the Pacific Coast, a pipe of moderate dimensions will have sufficient capacity for the development of a very considerable amount of power. Good workmanship and careful selection of material in combination with good design will ensure so excellent a pipe that danger of the plant being disabled through pipe failure will be very remote. Large pipes give considerably better efficiency than small ones for the same velocity of flow, a fact which is of considerable importance where water supply is limited, and it is desirable to obtain the highest possible efficiency of the system. Financial conditions may insist upon the first cost being kept at the lowest possible mark, such extensions as are required for the completion of the plant being paid for out of the earnings of the original installation. Again, physical conditions may become the determining factor and difficulties of transportation and laying may demand that a smaller pipe be used than good engineering would sanction, and indeed, the conditions which determine the use of a pipe of moderate dimensions will not be so very severe since the advantages, as to cost, possessed by a large pipe are mainly in labor and since the weight of a pipe with a given factor of safety increases in the same ratio as the volume, i. e., as the square of the diameter.

---

[*] A paper read before the Sacramento Convention of the Pacific Coast Electric Transmission Association, October 20, 1897.

The improvements in the hurdy gurdy or impulse type of wheel have resulted in the development of water powers under enormous heads and it is generally said that the use of such heads has brought to the surface many difficult and unexpected problems in connection with pipes and requiring much ingenuity and many experiments to overcome. The use of such heads has brought to the surface many problems in connection with the emission and use of the water, but the added problems in connection with the pipe line are few and have been very much overrated. One upon which great stress is laid is that due to the cessation of the flow of water, or the water ram effect, but this is absolutely independent of the head and depends only upon the volume of water brought to rest. It produces a strain of exactly the same magnitude in a pipe carrying water under a head of one hundred feet as it does in one used under a thousand feet, and relatively the strain is very much greater and therefore more dangerous in the case of the pipe under the smallest static strain.

This will be evident if some figures are introduced. A pipe carrying water under a working pressure of one hundred pounds and designed for a factor of safety of seven will have an ultimate strength of seven hundred pounds. If water ram should produce an added pressure of 250 lbs., the factor of safety would be reduced to two. If, however, the pipe is designed for a static strain of 500 pounds and water ram places on this pipe the same extra strain, the factor of safety will be 4 2-3, or with the same water ram the pipe under high head will be 2 1-3 times as safe as the other. Water ram under high heads is a genie which has troubled the Pacific slope since he was released from his Caucasian dungeon, by the too sudden closing of the valve at Fresno which resulted in a strain that was felt throughout the length and breadth of the land. It is probable that but for the bursting of that pipe the question of water ram would have had little general consideration though of course, the hydraulic engineer will consider it in all cases and so order his design as to make it as small as possible. The operator under very high heads has little to fear from it except in cases of such extreme carelessness as resulted in the Fresno disaster, and the appliances for controlling the water should be such as absolutely to prevent such an occurrence. In a plant operating under moderate and low heads the possibility of damage from this cause increases, and in case a long pipe of large diameter is conveying a large volume of water, means must be provided for preventing the sudden cessation of any considerable volume of flow, or, in case the circumstances do not permit this, the pipe must be designed for a much greater pressure than that due to the static head.

As an example of the magnitude this is likely to assume in a particular case, the calculation in connection with the pipe of the Blue Lakes Water Company may be cited. The pipe is about 3400 feet long with a mean inside diameter of about 22 inches. When it is delivering about 1200 h. p., the velocity of flow will be about 5 feet per second. Under these circumstances if the flow of water could be instantly arrested the pressure at the lower end of the pipe due to the inertia of the water would be about 275 pounds per square inch. Screw gates with small pitch of stem are provided so that the closing must be very gradual and the maximum theoretical possible pressure can never be approximated to. Experiment shows very clearly that even if a valve be closed with considerable rapidity, water ram cannot be manifested to a large extent as long as the valve has any considerable opening, the increase of pressure being checked by the escaping water. Automatic valves are sometimes suggested as a safeguard against water ram, but all such appliances add needless complexity and are best omitted. When inertia pressure is likely to add any considerable strain, it is best provided for by increased factor of safety in designing the pipe.

There is another variety of strain which may be set up by the variable motion of the water and which, when the circumstances are suitable for its production, may become very severe. I refer to the vibrations which are sometimes set up in a pipe lying on the surface and carrying a considerable volume of water. These need not be expected to any extent in a straight or but slightly curved pipe, but if a pipe has one or more considerable bends near the bottom and is not thoroughly anchored, the vibrations set up under a variable water flow may be very severe and in some cases they may be increased by the natural vibration period of the water column coinciding with the period of some rythmic motion at the lower end of the pipe or with some multiple of this period. In all cases where there is a liability to rythmic motion, there is a possibility of a very considerable resonance effect, though this is seldom admitted.

Bends in pipes under very high heads are to be avoided when possible not only because they cause a loss of head by changing the direction of flow, but also because they are unbalanced points in the system which require careful anchoring. Care is always taken to carefully anchor receivers, etc., and yet such bends are frequently neglected, though the necessity for anchoring is as great as in the case of the receiver. With unanchored bends the strain on the flange bolts or joint rivets is much greater than they are designed to carry, and the result may be the opening of joints enough to permit the flow of a small stream. Such stream has great cutting power and with the assistance of swirling sand, may quickly bore an opening sufficiently great to cause the shutting down of the plant. All movements of pipe due to variable motion of water; all expansion due to variable temperature; and all unbalanced strains due to bends, etc., may be eliminated by having the pipe well buried, as the holding power of the soil is very great.

While, under very high heads, the instantaneous stopping of water which is flowing with a velocity which can be countenanced by good engineering, will produce no strain likely to result in rupture, still such strains should not unnecessarily be placed upon the pipe and are best avoided by some form of valve which will not permit of too quick closing. A screw gate fills the requirement, as also does an hydraulic gate provided with necessary safeties, but the Fresno disaster shows that in some hands, safeties may be of no avail unless they are of such a character that they cannot be tampered with. The surest safety is an inlet pipe so small relatively to the cylinder that the travel of the piston cannot exceed a predetermined speed.

For extreme heads, either high or low, the type of wheel will be fixed beyond question, as for very low heads the reaction turbine is the only suitable machine, and for extremely high heads there is no doubt about the advantages of the small circular stream impinging in divided buckets of the Pelton type. For intermediate heads, wheels such as the Knight and the impulse turbines cannot be overlooked as they possess some very material advantages where considerable volumes of water are to be handled.

Of the Pelton type there are now a number on the market differing only in some slight detail of bucket. Some slight variation is necessary as a basis for a new name, but there is probably little to choose between the various shapes, as far as efficiency is concerned. Of far greater importance is the shape of the jet impinging in the buckets, as jets under such high heads are extremely sensitive and a slight variation in the shape of the tip may so alter the jet as to cause a great reduction in efficiency. The best results are obtained from solid, cylindrical jets, but there probably exist more spreading jets than is generally suspected. Every plant should be provided with a tip testing apparatus in which all the conditions under which the tips are to be used are duplicated. This should be placed outside where free discharge can be permitted and easy examination of the jet be made. Without such device the shape of the jet will be an unknown quantity. The valve should be placed so far from the tip that the whirling of the water due to the passage through it may be eliminated and the flow made to take place in lines parallel to the axis before leaving the tip. If this is not done a good jet cannot be expected.

The question as to whether single or multiple jets shall be used will generally be answered in favor of the single jet, when the power requirements are such as to permit it. If a wheel is required to develop a very large amount of power, multiple jets may become necessary, but when a single jet is possible its greater efficiency at full power, coupled with the greater simplicity of a single operating device, will generally decide in its favor.

The housing of a wheel will frequently be governed by considerations which are acoustic and optic rather than hydraulic. With a wrought iron housing the drumming of the water produces, under high heads, a most terrific noise which is largely eliminated by a rigid cast iron structure, also this material lends itself to a more pleasing design than does wrought iron.

Having overcome all the difficulties which opposed themselves to the free passage of the water to the point where it is desired to use it, and having provided a suitable wheel through the agency of which the power stored in the water may be made available, the engineer finds himself confronted by a problem the solution of which has proved to be more difficult than any of the others. I refer to the mechanism for so controlling the application of the water that the speed of the machines may vary through but narrow limits. Water wheels were formerly mainly used in flour mills, saw mills and other places where the load was comparatively steady or where considerable variation of speed was a matter of little moment, and a class of governors had been devised which acted directly upon the gates and were considered sufficiently good if they prevented extreme variations of speed. With the introduction of electricity and the application of water wheels for driving dynamos, governors of this type were found to be entirely useless and many attempts have been made to produce a more satisfactory design. These studies have resulted in the general adoption of the relay type of governor, of which there are several varieties having more or less extended application. They still leave much to be desired but their action is certainly a great improvement over that of governors formerly in use.

While governors of this type have great advantages, the sensitiveness which gives them their advantage is also the source of a difficulty which can only be overcome by the exercise of considerable care. If dynamos are operating in parallel and the water wheels are independently governed, and if one of the governors has a critical speed which is a little less than the others, it will shut off the water from its wheel until the load is practically carried by the other dynamos, or if there are but two dynamos in operation, one will be overloaded at full gate until the load pulls down the speed to that of the wheel whose governor has the slowest critical speed. This can, of course, be avoided by providing but one governor for actuating the water-controlling mechanism of all the wheels, and in some cases this may be feasible. It is impossible, however, if machines are sometimes to be independently operated on seperate circuits, as this condition will require that each dynamo or group of dynamos be independently governed.

Governing under low heads and great volume of water is also a different problem from governing under high heads with small and sensitive streams, and what is comparatively easy to accomplish in one case will require most careful adjustment for equally satisfactory results to be obtained in the other. The direction of flow of the water particles being of great importance with the small circular stream acting by impulse, almost inappreciable differences in the shape of the tips may result in very different power by different wheels when all gates are opened to the same extent by a single governor, or when deflecting nozzles discharging different shaped streams are placed in the same relative position. If a common governor is to be used in such cases, great care must be exercised to secure similar streams from all the tips. With low heads and great volume of water, the stream is less sensitive and multiple governing can be more easily adopted. Unless it is certain that the machines will always operate in parallel, it is best to provide independent governors having means whereby the critical speed can be adjusted while they are in operation.

Most governors of the relay type operate through change of speed only, but there is another class which, in theory at least, would seem to offer possibilities better than can be found in the purely centrifugal class. This is the class which aims to govern for violent changes of load through the direct action of such change, a variation of speed being anticipated. Two possible cases offer themselves—one makes use of the variable current output of the dynamo through the medium of a solenoid, the variable magnetic action being caused to open or close the valve very quickly, thereby checking the tendency to sudden change of speed, the relay principle being called into action for the fine adjustment. This case finds an example in the Lighthipe governor, which is reported to give excellent satisfaction.

The other case would make use of the tortional strain through the medium of which the power developed by the water wheel is transmitted to the rotor of the dynamo. As in the first case, it would anticipate sudden changes of speed, depending upon the relay principle for nice adjustment. As far as I know it has no working example, but from theoretical considerations it seems to offer better possibilities than any of the other designs.

Finally, the difficulties of governing diminish with increasing load, since any given horse power variation will represent a much smaller percentage of the output and the range of required governing will be comparatively small.

WATER WHEEL REGULATION.

By Samuel N. Knight.

DURING the past ten years there have been many attempts to improve regulating apparatus for water wheels, especially in the case of wheels employed to drive electrical generators where close regulation in speed is indespensable, but the problem becomes of the greatest importance when current for power purposes and for lighting are taken from the same lines.

During the past ten years there have been many attempts to improve regulating apparatus for water wheels, especially in the case of wheels employed to drive electrical generators where close regulation in speed is indespensable, but the problem becomes of the greatest importance when current for power purposes and for lighting are taken from the same lines.

Makers of water wheels and regulating apparatus well know the difference between a long and a short supply pipe in respect to the difficulties of regulation, and on the Pacific Coast we have had the extremes of this difficulty to contend with. In the Eastern states the heads are low and the conduit pipes so short as to scarcely involve the elements of momentum, which is a principal impediment in the West where the heads are usually hundreds of feet and the conducting pipes sometimes miles in length. The ordinary means of regulation are not applicable under these circumstances.

A long pipe filled with water is a moving solid, less elastic and less compressible than steel. It cannot be stopped and started except in a considerable period of time, and, when accelerated, can not be reduced in velocity except by another period of time, varying in common practice here from five to thirty seconds, or in proportion to the length of the pipe line from which the supply is drawn.

It is evident that under these circumstances, common throttling devices would be of no use and that a change of the regulating valve produced by variation in the speed of a water wheel would fail to have effect, so other methods have to be adopted.

Some makers of high pressure tangential water wheels employ what are called deflecting nozzles, by which the water is diverted from the wheel when not required, and its energy is lost. This method obviates the inertia factor in regulation and permits the pressure and flow in the pipe to remain uniform, but it leads to a waste of water equal to all variations below a maximum load and is too wasteful in any case when water is paid for in volume, or is scarce.

This method is especially objectionable when there are but two or three nozzles of large size, and is less objectionable when there are a large number of nozzles of small size; in other words the loss of water is as its subdivision and as the size of the jets or streams that are cut out and cut in for regulation.

In the case of either throttling or cut out regulation, and when the governing devices are controlled by an electric current from the switch board of a station, either by hydraulic pistons or solenoids, general regulation is easily adjusted by comparing a scale of the indicated horsepower with the watt meter, and the number of jets or issues can be adjusted to give the maximum power required.

In this manner, if the number of issues be five, and the variations of current do not exceed 20 per cent, all regulation will be performed by one issue or nozzle, and any loss of efficiency in this issue due to throttling would be divisible by five, so the losses of regulation would be inconsiderable.

This method does not, however, provide for inertia and momentum in the pipe line, and at the works of the Pioneer Electric Power Company of Ogden, Utah, where the pipe line is six miles long and six feet in diameter, the periods of change in the flow of water are supplemented by heavy fly wheels, that give out or absorb energy during periods of change. In this plant of 6,000 horsepower are surmounted perhaps the greatest difficulties ever encountered in respect to regulation, the latter being provided for in several ways, one of which is by over-flow or relay stand pipes designed by Mr. C. K. Bannister, chief engineer of the company.

These stand pipes, one of which is within one mile of the station, perform the functions of an air vessel, except that the resistance is as the gravity, and the motion is as the square root of the head, and in these respects it differs from the action of compressed air. The stand pipe mentioned, in effect, reduces the pipe line to one mile in length, but even this mass of water, weighing more than 4,500 tons, has to be handled with care. Its properties as to motion can be imagined by comparing it with a large ocean steamer, and how such a steamer could be moved backwards and forward to adjust the speed and energy of a water wheel.

Fly wheels placed on the water wheel shafts have to withstand an enormous speed of revolution, the strain exceeding the limit for cast iron, but within the strength of the best mallable metals, such as fibrous iron and alloys of certain kinds too well known to need mention.

The writer, who was the contractor for and constructed the hydraulic power equipment in the Pioneer Electric Power Company's plant at Ogden, adopted a form of regulating apparatus that was intended to form the principal subject in this paper.

This apparatus, of which there are five sets, are applied to as many water wheels giving out 6,000 horsepower. Upon inspection it appears to be an extensive and somewhat complicated device, but it contains only the elements required to perform the necessary functions to insure regulation under the extremely difficult conditions I have been pointing out. It is, of course, impossible in words alone, or even with the aid of drawings, to fully explain the mechanism and the particular manner of its operation. The best I can do is to describe in general terms the main elements and the principal on which they operate.

The Knight governor contains two centrifugal governors, driven at the same speed from one shaft. When the speed of the generators change, one governor acts by closing an electric circuit communicating to a magnet, or solenoid, that by means of a lever, engages a friction clutch and sets in motion machinery driven from the main shaft that opens or closes a throttling valve, or the induction issues of the water wheels. The electric circuit and action of the solenoids is not constant, however, if so the regulating action would outstrip the change in the motion of the water in the pipe line, so the electric circuit established by the governor's action is broken intermittently by a relay, the action on the water being confined to one-sixth of the time.

If under these circumstances the change of speed in the water wheels and generators is not accomplished by the first governor, the second one comes into action, and also closes the electric circuit to the solenoid, which current is also intermittently broken, but at longer periods corresponding to one-third of the time. In other words, the action on the water regulating apparatus is doubled by the second governor, if however, as is possible under extreme changes, this intermittent action of the regulating apparatus does not produce the required change of motion in the wheels, a third contact is made by the second governor and so the current and action of the solenoid becomes constant until the speed is checked or accelerated to meet the load or resistance.

This in general terms is the method of operating, carried out successfully in the case named, which is one of the most extensive installations in the world and certainly one where the impediments to be dealt with have no parallel in modern practice. Had the regulating apparatus been given a free range and continuous action between the extremes, the result would be destructive racing and no useful results could be attained.

In this case the adjustment of the electrical elements provide for twenty-four changes of the rate at which the clutches and water regulating gearing may operate. In other cases this range of adjustment can be less and the regulating mechanism as a whole be simplified, the mode of operating remaining the same.

I may mention that while the plans and construction of this regulating apparatus involve a good many intricate problems, these have been less difficult for the writer to deal with than this attempt to describe the work.

Protection Against Lightning

PAPERS READ BEFORE THE SACRAMENTO CONVENTION OF THE PACIFIC COAST ELECTRIC TRANSMISSION ASSOCIATION. SACRAMENTO, CAL., OCTOBER 22, 1897.

LIGHTNING ON TRANSMISSION LINES.

By Theo. E. Theberath, M. E.

BEFORE taking up the question of protection, allow me to touch briefly on the question of what lightning is and what are some of its properties. You are all familiar with the phenomena of lightning as it is seen during a storm, and I have no doubt many of you are familiar with its effect on electrical apparatus, both from a practical as well as a financial standpoint. It has long been an established fact that lightning is an electric phenomena and that it is the result of an accumulated charge of the character known as static electricity.

Static electricity, as its name implies, means electricity standing still and is a term used to distinguish it from dynamic electricity or electricity in motion. Lightning on a small scale was produced by the old experimenters in various ways, and as early as 1602, Otto von Guericke cast a sulphur globe in a glass sphere and then broke away the glass and he found by rubbing the globe with the hands, as it revolved upon an axis, that light and sound resulted from strong electrical excitation. Later Sir Isaac Newton used a glass globe for the same purpose. The source of energy of this miniature lightning in the above case was hand power applied to the crank handle used to revolve the sphere.

It is an undisputed fact that a stroke of lightning represents the expenditure of considerable energy, as evidenced by its destructive effect. The source of this energy is still an open problem and an attempt at its solution immediately leads one into the still unknown realms of that which is supposed to permeate all space and known as the "ether." It is considered that in all probability the whole Universe, or at any rate that part of it at present known to us, which extends for more than millions of miles away on every side of the solar system, is filled with a jelly like substance called "the ether" sometimes "the luminiferous ether." While the existence of the ether is a generally accepted theory, its qualities are but little known. Assuming certain quantities, Lord Kelvin gives its rigidity or resistance to bending as one one hundred and fourteen thousand million millionths of that of steel; its density in space about one hundred and twenty-eight ten-trillion trillionths that of steel. In all matter its density is somewhat greater than this, and in iron its density is much greater. Numberless explanations of the origin of lightning have been suggested and the liberty is taken here to add to the number; as a proper understanding of the properties of that against which we desire to protect may lead to a better understanding of the conditions to be met and the means to be applied to accomplish the desired object.

Taking our earth with its enormous surface of nearly 200,000,000 square miles revolving on its axis at the rate of 1035 miles per hour, and at the same time traveling around its orbit at the rate of 1800 miles an hour, and comparing it with the spheres of Guericke and Newton, we can form a comparative conception of the relative results obtained in the shape of an electrical excitation, and the resulting discharge therefrom. It is true that Newton and Guericke applied their hands to the revolving globes and that these conditions are lacking in our earth, as a static electric accumulator. Franklin showed about the middle part of the 18th century that electricity is not created by friction, but merely collected from its state of diffusion through other matter by which it is attracted. The earth however, is traveling through the ether which has rigidity and density, and as Lord Kelvin has stated, the density of ether is greater in matter than in space, we can consider a concentration of ether in the path of our earth, similar to the concentration of lines of magnetic force in the permanent or electro magnet. Furthermore, owing to the rigidity of the ether we can consider our earth traveling through a viscous medium. The rate of speed being greatest at the equator, there is an accumulation, so to speak, at this point and in consequence of the lower speed at the poles, this tendency is not so marked and a vortex or whirl is set up. This therefore sets up a difference of potential between the equator and the poles, and a consequent flow from the equator to the poles. That a re-distribution takes place at the poles is evidenced by the fact that when the conditions of the earth's atmosphere are favorable to harmonizing with the vibrations of the departing ether, or the interference of the atmosphere breaking up the wave lengths of the vibrating ether, the result is the sensation of light known as the Aurora.

From various experiments, such as were carried on by Franklin and others in the early days and also those carried on lately by the United States Weather Bureau with kites of the Hargrave pattern we can see that the redistribution of the ether takes place not simply along the surface of the earth, but that there is a movement of the ether through the atmosphere. Any surface, therefore, which is capable of receiving a charge, or in other words, any surface which will interfere with the free passage of the traveling waves or vibrations, if interposed in the path of these vibrations, will become charged with a difference of potential with reference to surrounding points.

The experiments of the United States Weather Bureau with the Hargrave kites prove this to be the case even in clear weather with a clear sky. It has therefore been clearly demonstrated that there is in existence what has been termed "atmospheric electricity."

It seems strange that we should have phenomena of static electricity of vast proportions under conditions which seem absolutely adverse for the existence of accumulated charges of static electricity; as it is a well known fact that in the laboratory experiments with influence machines in the production of static electricity, better and more marked results are obtained when the air is crisp and perfectly dry. Then why should we find in nature the existence of enormous charges of static electricity accumulated under most adverse conditions and produce discharges through an atmosphere not only moist but decidedly wet. This condition however, is easily accounted for when it is known that a drop of water can be electrified and retain a surface charge. It has been observed that sparks discharge from rain drops as they approach the ground. Snow flakes have been found to be charged, as shown by sparks drawn from an umbrella on which snow has fallen. As the water is evaporated from the surface of the earth and carried upwards through the air, it is gradually condensed from the gaseous to the liquid state by coming in contact with the upper strata of air which are cooler than those in the neighborhood of the earth's surface.

The small particles of water formed by this condensation unite together and form clouds, or if the temperature is low enough the vapor is frozen into a mist. In either case surfaces are formed which are capable of receiving a charge of electricity, or an accumulation, with a resultant difference of potential of such magnitude that it finally overcomes the intervening resistance and a discharge takes place with a rapid re-distribution or equalization of potential.

The theory advanced is thus briefly stated; that the motion of the earth through the ether is the cause of the accumulation of the energy producing the phenomena of lightning.

The clouds act as an interfering medium to the natural re-distribution of the accumulated energy, which is going on constantly. The disruptive discharge is the result of the difference of potential which is created when a charged body is brought in the neighborhood of another body, which in turn becomes charged in the opposite sense and thereby increasing the difference of potential until an equalization is brought about by its rapid dissipation of energy in the form of light, heat and sound vibration. We can practically consider the clouds and the earth's surface as forming two plates of an enormous condenser with the air as the dielectric between them.

In experiments with condensers it has been found, as stated by Prof. Sylvanus Thomson, "That if the termin-"als of a charged condenser are connected by a high re-"sistance, such as a nearly dry linen thread, the charge "simply dies away by a discharge which increases its "strength at first, and then gradually dies away. If, "however, the condenser is discharged through a coil of "wire of one or more turns (the spark being taken be-"tween polished knobs to prevent premature discharge) "the effect is of an entirely different character, for then "the discharge consists of a number of excessively rapid "oscillations or surgings. The first rush more than "empties the condenser and charges it the opposite way; "then follows a reverse discharge, which also overdoes "the discharge, and charges the condenser the same way "as at first, and so forth. Each successive oscillation is "feebler than the preceding, so that after a number of os-"cillations the discharge dies away."

That lightning follows the above conditions has been demonstrated in various ways. The air as a general rule is charged positively with reference to the earth, but, during storms, negative electrification has been noted as well as severe disturbances in the atmospheric electricity. During this surging back and forth of the ether, all surfaces in the path of the moving ether, become charged; if these surfaces are well insulated from the earth, such as the wires of a long distance transmission circuit, we may have static discharges from the wires even when the primary discharge occurred some distance from the pole line. If the line is well insulated from the cross arms and poles, as is necessarily the case with high potential circuits, the strain is transferred to the insulation of the transformers or generators and any weak spot in this insulation will allow the stored up energy to rush to earth with resulting damage to the apparatus.

It is therefore self evident that all that is necessary to protect our apparatus is to provide an easier path to earth for this stored up energy and in this way relieve the line of the static discharge. A ground connection with a spark gap interposed, is all that is required as far as the static electricity is concerned; but the gap once closed by an arc formed by the static discharge will allow the dynamic current to follow in its path and a short circuit will result if the discharge has taken place from both wires of the circuit.

While the means for relieving a line of its static charge is a very simple problem, the elimination of the short circuiting of the dynamic current is not so easily accomplished. Many ingenious devices to accomplish the opening of the short circuit produced, have been invented and placed upon the market. Some of these depended upon moving parts, but owing to the fact that lightning is not an hourly occurrence which would keep them limbered up, they were generally found out of order when the time came for action. The requirements for a good lightning arrester are as follows:

1. It must offer an easy path for the passage of the static current.

2. The spark gap must be small enough to allow the charge to dissipate itself before reaching a potential which would endanger the insulation of the translating devices.

3. It must prevent the following of the dynamic current.

With reference to the first requirement it has been found that in all experiments with static electricity, in order to get good results, the spark gap surfaces should be clean and bright. As soon as the surfaces become blackened and pitted it is found necessary to raise the potential considerably in order to get the charge to leap across the gap. It is very essential, therefore, that the arrester be so constructed that a large sparking surface is presented so that the care and necessity for inspection is reduced to a minimum. This property is a most desirable feature for arresters in connection with high voltage circuits and which are not desirable subjects for constant handling when the current is on the line.

In the selection of the proper spark gap it is necessary to take in consideration the quality of the insulation of the translating devices, the distance through which the static discharge can take place and at the same time providing against the establishment of an arc by the dynamic current. If the insulation of the translating devices is poor in connection with too large a spark gap, the translating device may act as a better lightning arrester than the instrument intended for that purpose.

Lightning arresters with moving parts have been entirely abandoned by nearly all manufacturers, and it is therefore unnecessary to dwell upon their construction. The style of arresters which are giving the best results at the present day, on alternating current circuits, are of the non-arcing metal type. The special feature of this type of arrester is the use of metallic cylinders or spheres, placed side by side with an air space or sparking gap between them. The number of cylinders or spheres and air gaps are proportioned with reference to the difference of potential of the dynamic current used on the line. The cylinders or spheres are constructed of a metal whose oxides are intended to produce non-conducting vapors. The metals which possess this property are of the well known chemical group of antimony, zinc and cadmium. Zinc, on account of its being the least expensive of the group, is commonly used, and in fact ordinary brass possesses all the properties of the so-called non-arcing metal. It has been found in practice however, that the non-arcing metal will arc at times and cause a short circuit on the line. This may have been due to the use of too much copper in the original mixture or it may have been the result of several discharges having passed between the same points. Under this condition the surfaces adjoining the spark gap may have been reduced to a copper surface and the resulting vapor having conducting instead of non-conducting properties. To avoid the above conditions it was found advisable to turn the cylinders after a discharge had passed over the gap so as to present new surfaces. Short circuiting has also resulted from insufficient insulation between the terminal points for the line connections. In some of the arresters the terminal connections are placed on a marble or porcelain slab with its surface in a horizontal position. This arrangement allows the accumulation of dust and dirt upon the surface and a short circuit between the terminals may be the result. The danger of short circuiting the terminals is generally encountered in the use of a single arrester on one or two thousand volt circuits; as in this case the potential strain of the circuit is brought at the two extremities of a horizontal surface of marble which acts as a dust collecting shelf.

Arresters using the non-arcing metal principle have been constructed in various ways with reference to the shape of the surface presented to the spark gap. The universal custom of using metal balls as discharging surfaces in all experiments with static electricity led to the construction of an arrester composed of a number of spheres or balls of non-arcing metal mounted on insulating material, with spark gaps between them. While this style of surface is well adapted for use in connection with purely static discharges, it is absolutely useless where a static discharge is liable to be followed by dynamo current. The sphere presents only two points as the shortest distance between their surfaces. A single discharge will blacken these points and the second discharge must be of a higher potential, to either overcome the greater resistance of the oxidized surfaces or the resistance of the greater air gap between the clean or un-oxidized surfaces.

The arrester using parallel cylinders has an advantage over the sphere in the fact that the air gap is of the same length for the whole length of the two parallel elements of the cylinders and a greater number of discharges can pass over the air gap before the resistance of the gap is increased by the complete oxidization of the surfaces.

An arrester has been designed recently which consists of a series of concentric cylinders with flaring tops; the cylinders are held in place by perforated porcelain caps. The air gaps between the parallel sections are of such length that the e. m. f. necessary to spark the gaps is less than the e. m. f. necessary to rupture the insulation of the system. The arrester consists of two portions, each being held in place by separate porcelain pieces. The line terminals are connected to the center post in the center of the larger porcelain caps. The insulation of the terminals is very high with this arrangement, and it is impossible for the accumulation of dust or bugs to start an arc between the terminals.

It is very apparent that with concentric cylinders the greatest surface is presented to the sparking gap and a larger number of discharges can be taken across the gaps before it becomes necessary to change the cylinder. The air gap is of the shortest length at the bottom end of the cylinders and at the point of flare the space between the conical surfaces gradually increases. The static discharge will leap across the gap at the narrowest point, and the natural draught of air set up by the heat of the arc causes an upward travel of the arc, along the increasing air gap until the interruption of the dynamo current takes place.

This arrester combines the non-arcing principle with a natural air blast to rupture the arc. Three concentric cylinders are used with three air gaps forming a unit for one thousand volts, and for the higher voltages a number of these units are connected in series.

In connection with the lightning arresters it is advisable to insert self induction coils in the line between the point of attachment of the arresters and the apparatus to be protected. Owing to the fact that lightning discharges are of a pulsating nature of very high frequency, it has been found, that a small amount of self induction, in the shape of a few turns of wire, will offer an impedance, sufficient to force the discharge to take place to earth over the path of the lightning arresters instead of the path through the apparatus.

The introduction of self-induction in an alternating circuit is an undersirable feature as it assists in lowering the power factor. The objection to the use of impedance coils has been removed in a novel way in one of the recent installations of the Stanley Electric Manufacturing Co. In this case two self-induction coils are connected in opposition to each other in the same leg of the circuit. This is found to practically eliminate the self-induction as far as the dynamo currents are concerned, but at the same time offering high impedance to the current of the static charge. This method is better and safer than the one used by Bradley, which consists of two coils, one in each leg of the circuit, and so arranged that the outgoing and returning current neutralizes the self-induction in the coils. This is a difficult arrangement to insulate for high voltages.

Lightning protection should be installed at each end of a long distance transmission line and at the terminal points of all its branches. If the line passes through a section of country where lightning is of frequent occurrence it would be well to protect the line at the most exposed points.

The old saying that "An ounce of prevention is better than a pound of cure" applies admirably to the case of protection against lightning discharges. If it were possible to keep the earth, and other surrounding objects in the neighborhood of the pole line, constantly discharged, or in other words, prevent the clouds from charging the line and surrounding bodies with a difference of potential, all danger of damage by lightning would be eliminated. A barbed wire, well grounded, strung over the top of the poles will assist in keeping the ground and the line discharged, but this should not be depended upon as the only method of protection. A plentiful supply of line aresters, well placed on the distribution circuits will afford protection to the transformers scattered along the line.

Owing to the oscillatory and surging nature of the charge on the line, it has been found that nodal points are established and that the discharge is somewhat selective in its nature. For this reason it has been found advisable to arange the banks of lightning arresters on high potential circuits in such a way that several paths are offered. As an example of this consider two impedance coils connected in opposition to each other and in series with one wire of the circuit. From the point of connection between the two coils and their extreme ends, take off three taps to three 1000 volt units; then connect these three units to two, and then continue with single units of sufficient numbers to equal the voltage of the system. Then connect the ground terminal of the last unit to a good earth by means of a galvanized iron strip, clamped between porcelain cleats. The advantages of a galvanized strip are, that a flat surface is a better conductor for static charges and the flat iron ribbon offers resistance to the passage of the dynamo current when mounted in the way specified as above.

LIGHTNING AT SACRAMENTO.

By C. W. Hutton.

ACCORDING to some recent estimates, the losses to electric companies, due to electric discharges, are between $250,000 and $350,000 annually. Although the subject of lightning and methods of protection has received a great deal of attention in the past ten years, the above figures would tend to indicate that there is still considerable room for improvement. The fact that there are so many electric transmission plants that have sprung into existence in the past two years with their long, exposed lines; high potentials; large powers, and with the immense amount of money that is invested in step-up and step-down transformers that are directly but unavoidably connected to these long, exposed lines, makes the subject of protecting the apparatus against outside influences of still greater importance.

The function of a lightning arrester in any electric installation is to relieve the conductors of any excessive electric potential differences that may exist between them and the earth, and at the same time prevent an excessive flow from one conductor to the other, should there be a simultaneous discharge over any two conductors differing in potential.

In the case of a distributing circuit, where apparatus is promiscuously connected along its entire length, a single set of arresters at one end or at both, no matter how perfect in construction and operation they may be, would not of necessity protect the connected apparatus. The reasons for this are not obvious.

In the language of a well known authority: "That which we see and call lightning, is not a simple passage from cloud to earth; it is a vibration; the lightning oscillates back and forth. The oscillatory character of lightning and of disruptive discharges in general give rise to complicated phenomena. Electric oscillations or waves interfere with each other much as water waves interfere with each other. If, for example, a trough of water be raised at one end and then quickly lowered, the water in the trough will quietly surge back and forth.

If the end of the trough be raised a second time, a new system of surging may be started, and in such manner that the two will interfere with each other, and cause splashing at certain points, where crests of the two systems combine to form higher crests. Calm or smooth places will be noticed at points where a crest of one system has been neutralized by a trough of the other system. In electric wires we have somewhat analagous conditions during thunder storms. We have what a sailor would call a 'choppy sea.' The calm places and the splashing places are very close together, so that a lightning arrester connected anywhere in the line may, for aught we know, be connected at a calm place or at a splashing place.

It is obvious, then, from this, that the only effective way to protect a distributing circuit is to have enough arresters connected and distributed along the line, that for all conditions some of them shall be found at the crests where the disruptive discharges take place. It has been found by experience that the ends of the circuits and the ends of the branches are the parts subject to the greatest danger of burn-outs. At one plant in the City of Columbus, Ga., where a great deal of trouble was experienced from lightning discharges, it was found that in every instance where a transformer was connected at the end of a branch or circuit, it would invariably be burned out in the first storm. Bearing in mind that the ends of the lines were the parts most effected, the difficulty was remedied by running the lines one or two spans by the transformer, and tapping in a lightning arrester at the end. Even the arresters had a hard time of it, and a great many of the older type were burned out. Since substituting a later and improved type of arrester, and cutting in choke coils between the transformer and the line, no burn-outs have occurred.

In the case of the transmission lines, the conditions are somewhat different, as the apparatus is usually all at the ends, except the poor insulators, and, for aught we know, those poor insulators may be in the same condition that the country was a year ago—perhaps protection would exert a stimulating influence. Who knows but that during damp weather, while these high potentials are being generated in our long overhead lines by simple disturbances of the atmosphere, many insulators are punctured, and in the midst of the first storm the current takes advantage of the weak insulators, the pins are burned off and the insulators topple over. We say that these insulators broke down under a strain of 10,000 volts. Who knows but that it was subjected to perhaps several times that amount? It would appear, however, that the ends of the lines are points that need the most protection, and, as far as I know, as at present constructed, all transmission lines are protected at the ends only.

The experiences of the Sacramento Electric, Gas & Railway Company, with lightning have been very trifling—five shut downs are all that can be charged to lightning effects. Three of these occurred before the installation of the arresters at either end, and the effect of two of these was simply to throw the synchronous motors out of step, and in the early days of the plant, the slightest disturbance of any kind was the signal to shut off the current, and find out by telephone if everything was all right at both ends. No damage was done on the occasion of two of these shut-downs, and there was but a few minutes delay each time. The third one, however, caused a two-hours' delay. The lightning came in, and in some inconceivable manner, jumped from the high tension to the low tension side of the step-up transformers without even leaving a visible trace, and then went down the back of the generator board and burned off all of the voltmeter and synchronizing switching apparatus, and the plant was shut down two hours to make repairs. Since the installation of the arresters, there have been two shut-downs. These occurred before any resistances had been cut in series with the arresters, and when a discharge took place, the heavy current that followed dropped the voltage to such an extent that the motors, while under load, would fall out of step, but, as in the former cases, no damage was done, and only a few minutes delay was the result. Since the installation of the arresters and the resistances complete, very little trouble has been experienced.

On the afternoon of August 18th last and the morning of the 19th, quite a number of discharges took place, and especially on the morning of the 19th, there was quite a severe storm, and the discharges took place in quick succession, there being as many as fourteen in thirty minutes. The only effect, however, was simply to wink the lights and cause some slight churning in the speed. A volt-meter card was taking showing the effect of these discharges. Of course the throw of the needle was considerable, and would not, therefore, show accurately the drop of potential, but it shows how effectually the arresters took care of the discharges.

On the night of October 5th of the present year, the plant experienced an ugly shut-down, but its cause, I think, cannot be attributed to lightning. The lightning arresters, however, were very badly burned. The trouble happened in this way. The synchronous motors fell out of step, and the arresters flared up terribly; flashes came out of the telephone, and communication with Folsom was broken. When this happens, the man in charge at the generators is instructed to keep current on the lines if possible, so he kept pumping into the lines for about ten minutes, and seeing that something unusual had happened, he finally shut down. During the trouble, however, the dynamo tender at the Sacramento end commenced pulling the high tension swithces, and in so doing an arc was formed that burned off one set of wires that run into the switchboard from the north pole line. After current was cut off, the telephone worked all right and the man at Folsom was told to start up on the three remaining circuits, as there are four complete circuits altogether—two on each pole line. Still there was trouble on the lines, and word reached the station that a wire was down in a certain street and was making klinkers out of the gravel. In the meantime some of the arresters and resistances suffered severely. Some of the arrester balls were fused together and the resistances burned out. This is accounted for from the fact that when everything is intact, that there are two resistances and two arresters in series between any two wires, and in this case with one wire on the ground the arrester and resistance connected to this line would be shunted, leaving only one arrester and one resistance with the full potential of 10,000 volts across it, the consequence was that the arrester could not break the arc that formed, and the result was as indicated. The two circuits, one of which was grounded, were on this line of poles, and were cut out and we were ready to start on the one remaining circuit on the other pole line. We were delayed, however, as all the telephone apparatus of three distinct lines was knocked out and we were shut down one hour and ten minutes, instead of thirty-five minutes, as we would have been had the telephone worked properly. The cause of the line burning off was that some twigs of a tree had blown over against the wires, and it is my opinion that an arc was sprung between two neighboring wires, causing one of them to burn off. It is hard to say certainly that it was a "short" that burned off the wire. It may have been done simply by the twig coming in contact with the wire alone, but the neighboring wire shows quite a burn, and when the lights first went down they seemed to hover for a few seconds, and it looked as though there was a "short" through some very high resistances. It is, therefore, presumed that a "short" did the mischief, and not the mere grounding of the wire by a damp twig.

LIGHTNING IN NEVADA COUNTY.

By E. J. De Sabla, Jr.

BRIEFLY our troubles with lightning discharges on the transmission circuit of the Nevada Co. Electric Power Company have been comparatively few. However, I will endeavor in a few words to give our experience in the matter.

We have two Stanley 360 kw., 16,000 alternation generators, delivering 5,500 volts directly to our lines. The arrangement of the wires on our pole line is as follows: Poles are set 106 feet apart and carry two four-pin cross arms, eighteen inches apart, and two brackets six feet below the lower cross arm. On the tops of the poles is run No. 6 B. and S. galvanized iron wire, spiked to the wood with long wire spikes clinched over the wire; the ground-connecting wires on every other pole are soldered to the main wire and stapled to the side of the pole, also soldered to the ground plates, which are sheets of galvanized iron three feet wide wrapped around the butts of the poles. The pins in the cross arms are eighteen inches apart, on which are placed Locke triple petticoat porcelain insulators, on which are run the transmission wires, each one eighteen inches from the wires each side and the one below. The eight wires give us two complete circuits of four wires each, and each phase of two independent wires which are carried to all parts of the system. The brackets above mentioned carry the telephone line each side of the instrument, was found to give ample protection, but had to be repaired after each discharge.

The first thunder storm we experienced after starting was in the latter part of May, 1896, early in the morning. The discharge mistook our static ground detectors for arresters, and as we had failed to protect them by suitable fuses, the result was a dead short circuit and the destruction of one of our instruments. At that time we were using only one circuit and had only a lighting load. The strange part of this experience was that only one phase was affected, and that one was nearest to our ground wire, and we would think ought to have been least disturbed, the other phase not being disturbed noticeably. After this we decided to install lightning arresters in double bank at each terminal of the line; viz., at the power house, at each sub-station, and at each large motor outfit.

When the second thunder storm came in the latter part of September, 1896, at 4 P. M., we had but one motor in operation; viz., a 120 kw. two-phase synchronous motor operating an air compressor; we also had about 3,000 lights connected at the time. Both our generators were running independently, one on the power circuit, the other on our lighting circuit; the extra arresters had been installed at the two sub-stations, but not at the synchronous motor. Each discharge produced a momentary short circuit, caused evidently by the discharge passing the arresters. About the third time this happened, the synchronous motor dropped off when the circuits were thrown in parallel at the power house on to one machine; the next discharge produced a heavy short circuit, and the machinery was stopped, but started again in a few seconds, everything being apparently all right; but our Grass Valley sub-station soon signaled to shut down, it being found that the current had jumped across the open terminals of the phases at both Nevada City and Grass Valley (as all of the wires had been connected to the board so that the lighting load could be carried on either circuit). The burned marble was scraped clean and the storm having passed, the plant was started up, having been shut down only a few minutes.

It was found later that all the terminals of the synchronizing transformers for the large motor had been burned off, and that all the fuses on the starting motor transformers were blown, but aside from the small transformers no serious damage was done. No arresters had been put in for this motor, and hence the trouble. The next trouble came the last day of February, 1897, when we lost a 300-light step-down transformer at the Nevada wires, which are transposed every fifth pole.

It was thought at first that ample protection would be given by the heavy iron wire described above, but some weeks before starting the plant we had our telephone instruments badly damaged by lightning; this experience brought out the importance of more protecting devices, and a single set of Wurtz non-arcing out-door arresters were installed at the power house and arranged as the manufacturers directed, using an impedance coil of wire wound seventeen turns on a three-inch gas pipe. We supposed that the telephone line, being so far below the iron wire, would be thoroughly protected, but as stated the telephone system suffered from the start. To protect our instruments until we could install something permanent, a three-fourths inch iron bolt connected to the ground was wound with two or three thicknesses of paper and over this a half dozen turns of copper wire in the City sub-station, causing a shut-down for a few minutes.

The iron wire before mentioned got itself into disrepute by coming loose from its fastenings and grounding and short circuiting the lines at the most inopportune moments, so that it needed very little coaxing on the part of the electrician to get permission to cut it loose from the ground entirely, it being left in shape so it could be connected up conveniently if thought necessary. As a result we have a much improved telephone service, and some saving in power; we also note that we have had no telephone damage since the change. The electrician is not entirely vindicated yet, however, for in August last, we lost a 500-light step-down transformer at Nevada City during a thunder storm. However, this transformer had been seriously strained when it was first put into service, and had for many months been doing double duty. It is thought that our troubles from this source are aggravated by the fact that the lines cross the streams at right angles, and that there is an excessive difference of elevation between points on the line only short distances apart. For instance, at the power house the elevation is 1,400 feet, twenty poles from the power house it is 2,600 feet. The only fact that gives any permanent color to this theory is that we have five miles of line running from Grass Valley down the ridge to our arc plant purchased from the former lighting company in Grass Valley, which plant we still operate) and has never to our knowledge been disturbed by discharges, and has no protection whatever; this old line carries two arc circuits and a telephone circuit.

The thunder storms we have experienced come down from the mountains and although we do not know their tracks definitely, some pass the power house, spending their energy before reaching it, and others pass below or near Grass Valley, very few having passed Nevada City.

"Permit me to express my pleasure in reading the Journal of Electricity. You are furnishing us with an admirable paper and I trust you will prosper in the enterprise and continue to favor us, especially with illustrated descriptions of long distance transmissions."
—W. M. Stein.

LIGHTNING AND LONG TRANSMISSION.

By E. W. Sutcliffe.

It would almost be possible to treat of our theme as did the historian of Ireland, who, when he came to his chapter on snakes, in his general description of the resources of the Emerald Isle, began and ended the matter by simply saying: "There are no snakes in Ireland." It is almost true that we have no experiences.

Hence, of information concerning the freaks of lightning, as drawn from our own observation, there is little to impart. Lightning along our lines is infrequent and seldom violent. Only one severe electrical storm has swept over us, and the damage it wrought was insignificant.

Let us premise that we are protected by Westinghouse apparatus, the power house at Newcastle and the sub-station at Sacramento being guarded each by a battery of eighteen choke coils and one hundred and twenty-six non-arcing cylinders, forming type C, lightning arresters. This is on the high potential transmission line. At the sub-station, circuits going into the distributing system are equipped with one double pole non-arcing line arrester for each wire, but with a common ground for each pair.

Our wires have been struck several times, and we have seen and heard the discharge, as it danced across the arresters with a crackling noise; but it has always made its way safely to the ground.

Occasionally we have found that coincidently with the discharge the speed of the station motors, which drive arc dynamos, has increased 10 to 15 per cent.

On one occasion, during the very severe storm alluded to, our lines were struck near Newcastle, and the lightning formed an arc in the power house across the arresters, and the machine current held it there until the voltage was dropped. The same ocurrence repeated itself about five hours later, the arc holding out for several seconds. During the same day of unusual electrical disturbance, a discharge at the sub-station in the city blew the fuses at the power house in Newcastle, and momentarily shut down the plant. It looked as though the current were dammed back and found relief twenty-eight miles away in the melting of the fuses.

We consider the discharges on our long transmission line not nearly so severe as those we have observed on street railway lines in regions no more exposed to lightning, in California; which fact we deem to be owing to increased facilities on an extended pole line for dissipation through poles, trees, etc.

We consider our arresters efficient and feel ourselves well protected, the only visible result on our protective apparatus so far having been a slight blackening of the metallic cylinders.

On our secondary circuits of 2200 to 2400 volts, we have had no trouble that we can certainly attribute to lightning. Two converters have been lost during storms under supicious circumstances, the insulation of the primary coils having been pierced at one point by a hole only one thirty-second of an inch in diameter. No effect was noticed at the station; and we conclude that if lightning on the city lines has ever discharged in the central station, it has been safely grounded by the protective apparatus.

We propose the following queries:

Can lightning produce the damming back of a current and a rise in voltage at generating point analogous to the bursting effect of a sudden shutting off of water under momentum in a pipe?

If so, why have not our city sub-station fuses been blown when discharges have entered our distributing lines?

Might not this damming back of current sometimes prove as bad as a direct grounding of the lightning through the machines?

Is a longer transmission line in greater danger on elevated portions of the country than on those which lie lower?

Is there any feasible, simple method of protecting transformers, scattered over the distributing system?

INSULATORS FOR TRANSMISSION LINES.

By John Martin.

ONE of the most important questions which presents itself to the engineering fraternity who are exerting their efforts to utilize the vast water powers in this State and elsewhere, that have been for ages wasting their energies in wearing away rocks and washing mud and sand to the lower levels, is the problem of insulating the line wires of a transmission circuit so as to withstand the severe strain of the higher potentials which are now being used in order to bring nature's bounteous energy from the distant mountain ranges to the assistance of struggling humanity, and to enable them to cope more successfully with the ever-present problem of economics that is being forced upon them by the gigantic march of progress throughout civilization. The generation of high potentials has been brought to a state of perfection, and while it is a question of insulation, the conditions encountered are perhaps more favorable than the insulation of a wire which is exposed to the elements.

In the early days of electric transmission, when the power house was always located as near the center of distribution as possible, the ordinary glass insulator, which had been designed for the low potential service of telegraph work, was found all sufficient to give proper insulation to the fairly well insulated wire used in constructing these circuits. When, however, the potential of the circuit is raised into the thousands of volts, the wire with ordinary line material becomes a case of "paying too much for the whistle," and the money expended in paying for a complete coating of insulating material at the price of copper per pound had better be expended in a higher grade of supporting insulator which will protect the line at its most exposed points.

We are living in an age of progress, and intercommunication with the old stage coach, while it still exists here in this State and elsewhere as a matter of necessity, is no longer the only means of bringing the population of widely separated sections in touch with each other. The extension of our railroads, with the constantly increasing train speed and the vast increase in traffic, made it desirable and necessary to comunicate rapidly with distant sections of the country. In order to accomplish this, it was found necessary to increase the working potential of telegraph lines, and in its train came the demand for a better class of insulators.

During the battle between the demands of progress and the efforts of humanity to meet the imposed requirements, Mr. F. M. Locke was employed as a telegraph operator on a division of the New York Central & Hudson River Railroad, and also on the Pennsylvania Railroad Company. During wet and foggy weather he experienced difficulty in keeping the instruments which operated on the long lines in adjustment. On several occasions he was reported and censured for not answering his call. On one particular occasion Harrisburgh started to call him and he opened his key to answer, but found on closing it again that Harrisburgh was still calling. This puzzled him, as there was but one wire and that grounded at each end. Being of an inquisitive nature, he set out to determine the cause of such conditions, and found that the insulators were completely coated with a film of moisture, resulting from a fog. As this condition existed on a large number of insulators, the greater portion of the current returned to Harrisburgh through the shorter circuit by leakage over the surface of the insulators, and the opening of Mr. Locke's key did not interrupt Harrisburgh's circuit.

It naturally occurred to him that by increasing the surface length between the point of attachment of the wire and the cross arm, as well as the proper designing of the insulating surface, the tendency to surface leakage would be reduced. He started experimenting in a rather novel way with various kinds of insulators tied to the main line by the regular wire groove and a wire attached to the inner side of the pin hole, using his tongue as a galvanometer. After receiving several severe shocks from insulators with short surfaces, he was more careful in the selection of an insulator with a longer surface between the wire groove and the pin hole. This led up to the idea of increasing the number of petticoats and also increasing the diameter and lowering the height. The lowering of the height had the advantage of bringing the dripping edge closer to the cross arm and the increase in diameter brought it further away from the pin.. For further protection the middle petticoat was made to extend below the outer edge so as to further protect the inner petticoat and the pin. Patents were taken out by Mr. Locke covering the various improvements and the credit must be given him for the pioneer work in the development of a multi-petticoat insulator, which has since been adopted for all high potential transmission circuits.

Dr. Louis Bell is quoted as having said that the best insulator is an ordinary five cent coffee cup, and in correspondence on the subject with Prof. Perrine, of Stanford University, he was informed that if the same amount of money had been expended in the perfection of the High Potential Porcelain Insulator, that had been expended in the perfection of manufacture of the five cent coffee cup, the product would now be more perfect and better suited to our needs.

Porcelain was used in the manufacture of insulators in order to get greater strength and to overcome the hygroscopic nature of glass insulators produced at that time. The production of a good porcelain was not well understood by our American manufacturers, and the first porcelain insulators produced were not as good as glass as far as insulating properties were concerned. Improvements have been made in the methods of manufacture and the following process has been found to give the best results.

The mixture is made up from a high grade of spar, which has been calcined and ground to a fine powder, finely ground flint of the best quality, and a quantity of the finest plastic white clay. This is thoroughly mixed together in wooden tanks with water, and then run over bolting cloth screens of a very fine mesh, to take out any coarse particles; it is then strained through a cloth to separate the "slip," as it is called, from the water. The slip is then dried to the proper degree and formed into insulators; then set away to dry sufficiently so they can be handled without destroying their shape. They are then placed in the upper part of the kiln and baked just enough to dry off the moisture. In this shape it is called a soft biscuit; this biscuit is then immersed in a mixture composed of the same material as the body of the insulator, but the proportions are varied by the use of a greater quantity of spar. After the biscuit has been immersed in this solution they are allowed to dry for a short time, and then put into the kiln and fired at a high heat. At this high temperature the water of absorption and crystalization is driven off and the greater quantity of spar in the surface mixture produces a perfect glaze of practically the same material as the body. An insulator produced in this way will not crackle or "craze" when exposed to variations of temperature. Great care must be used in annealing all insulators, as a sudden change from the high heat of the kiln would crack the glaze of the best porcelain. Insulators coated with a glazing similar to soft glass may pass test and be put on the line but after a year or so the surface may be found full of cracks, or crazed, and the accumulation of dust and dirt result in serious surface leakage.

A porcelain insulator should be vitrious through the entire body and the co-efficient of expansion of the surface material should be the same as that of the body. It is an open question as to the relative advantages of a poreclain insulator properly made, against a properly constructed glass insulator which has been properly annealed. It is claimed that the difference between the hygroscopic properties of porcelain and glass cannot be measured, and there seems to be good ground for this assertion.

After analyzing the great difficulties which are encountered in the manufacture of porcelain insulators, and the inefficiency of visual inspection, the glass insulator presents a better front in two particulars; it will not puncture, and defects are readily discernible with the eye. By the proper annealing of glass, the objection of extreme brittleness is removed. The question of leakage (if in excess of porcelain) can be overcome by proper cross arm and pin installation.

SUPERIOR TO ANY JOURNAL PUBLISHED.

"Enclosed please find money order for $5.00, with which please keep my subscription to the Journal of Electricity going until said $5.00 runs out.

"I wish to express my appreciation of the very excellent articles published in your journal, and also of the illustrations, which I think superior to any journal published", writes Lewis Searing, Consulting Engineer of The Denver Engineering Works Company, of Denver, Colo.

Personal

Mr. H. W. Goode, general manager of the Portland General Electric Company is in San Francisco.

Mr. Sidney Sprout and wife left San Francisco on the 15th for the East. They will be absent about a month.

Mr. S. Morgan Smith, of York, Pa., was among the visitors that attended the Sacramento Convention of the Electric Transmission Association.

Mr. F. F. Barbour, manager of the power and mining department of the San Francisco office of the General Electric Company, is now in the East.

Mr. A. E. Brooke Ridley has gone to London and will probably not return to San Francisco before early in December.

Mr. George D. Greenwood, manager of the California Electrical Works, has returned to San Francisco after an extended business trip throughout the East.

Mr. L. S. Boggs, electrical engineer of the Pioneer Electric Power Company, having completed the installation of that interesting transmission plant, recently spent a well-earned vacation in visiting the various electric transmission plants of California and Oregon.

Mr. J. A. Lighthipe, chief engineer for the Pacific Coast District of the General Electric Company, and who has been dangerously ill for several weeks past, has gone to Bartlett Springs, where his many friends sincerely hope he will find an immediate restoration to health.

Mr. A. P. Breyton, president of the Pelton Water Wheel Company and who has been confined to his home with pneumonia for nearly five months past, has recovered sufficiently to be about again and on November 2d, sailed for Honolulu, where he will winter.

Telegraphy

THE INFANCY OF THE TELEGRAPH.

An appreciation of the convenience that would arise from an ability to carry on conversation between distant points by means of pre-arranged signals is evidenced in history before the discovery of America, and even the ambition of the most advanced electricians of the present day to effect a system of telegraphing without wires was thought of (in a most primitive way, to be sure,)in the beginning of the sixteenth century. The first recorded suggestion for what may be termed "wireless telegraphy," aside from the references to be found in early Greek and Roman and possibly Chinese literature, is related by a Scotch contemporary to be the plan devised by Paracelsus, the alchemist (1493-1541), and described by the English "mystic," Robert Fludd (1574-1637,) who wrote:

Two friends who wished to converse at a distance proceeded thus: A piece of skin was cut from the arm of each, and these fragments were "transplanted," so that either party had a portion of the cuticle of the other engrafted on his person. When separated from each other, at a given hour one of them traced on the piece of alien skin with a metal point the letters of the words of his message, and his friend could read these letters on his own arm, no matter how far they were separated.

Another plan was referred to by Strada, the Italian historian (1572-1649), in "Prolusiones Academicae," published in 1617. He stated that two needles magnetized by the same loadstone retained sympathy no matter how far they were separated, and that deviations made by the one needle would be reproduced by the other. This idea of "sympathetic" magnet needles seemed to find much favor , as it was referred to in several scientific and philosophical treatises in the seventeenth century. Meanwhile the researches intó the nature of electricity had been slowly progressing in France, Germany and Britain. It had been found that a current of electricity could be transmitted for a considerable distance through an iron or copper wire. In 1746 Le Monnier sent a current through an iron wire about 2,000 yards long. In the following year Dr. Watson transmitted a current across the Thames at Westminster Bridge, by dipping wires in the water and using the river as a conductor. But it had not occurred to anyone that this power might be used for signalling from one point to the other. The honor of suggesting this idea belongs of course to "an unknown Scotchman."

In the "Scot's Magazine" for February, 1753, a letter appeared dated "Renfrew, February 1, 1753," and signed "C. M." It was headed "An Expeditious Method of Conveying Intelligence." The anonymous writer proposed that a set of wires equal in number to the letters of the alphabet should be extended horizontally between two given points, and kept separate by being fixed at the ends in two plates of pierced glass. The wires were to project six inches beyond the glass plates, and a pith ball was to be suspended from every wire. About an eighth of an inch below the row of balls a case was to be laid containing the letters of the alphabet printed on thin paper. The operator at one end would transmit a current of electricity through one of the wires by connecting momentarily with an electrical machine and the pith ball at the other end would attract the thin paper with the printed letter. By manipulating the wires the words of a message could be spelled out. This writer further suggested as an alternative that bells might be used instead of the letters, and a signal alphabet could be constructed. "C. M." also suggested a coating for the wire in the following passage: "Some may perhaps think that although the electric fire has not been observed to diminish sensibly in its progress through any length of the wire that has been tried hitherto; yet as that has never exceeded some thirty or forty yards, it may be reasonably supposed that in a far greater length it would be remarkably diminished, and probably would be entirely drained off in a few miles by the surrounding air. To prevent the objection, and save longer argument, lay over the wires from one end to the other with a thin coat of jewelr's cement. This may be done for a trifle of additional expense, and as it is electric per se, will effectually secure any part of the fire from mixing with the atmosphere."

In 1765, a Genevan, Georges-Louis Lesage, devised a system of transmitting messages similar to the above method. His manuscript was submitted to Frederick the Great, but went astray at Berlin. It was not published until 1782. Five years afterwards Arthur Young stated that he had visited at Paris a mechanician called Lemond, who showed him a method of communicating messages from one part of the house to another by means of an electric wire. In 1796 Francisco Salva, of Madrid, proposed to signal between Bercelona and the island of Majorca by means of a sub-marine cable, using the electric machine; but at a later date he substituted the voltaic pile as his source of electrical energy. Soemmering suggested in 1809 that the galvanic battery should be used for this purpose; and he actually showed at Munich in that year a system of telegraphic signaling. About forty years before this time attention had been re-directed to the magnet needle as a means of communication. An Italian priest, named Beccaris, published a book in 1772 on "Artificial Electricity, in which he showed that electric circuits engendered magnetism. His theory was confirmed in 1802 by Romagnosi, of Trent; and in 1804 Dr. Mojon, of Genes, proved that unmagnetised needles acquired magnetic polarity when placed in a galvanic current. The way was thus prepared for Oersted, and in 1819 he announced his discovery of the deflection of the magnetic needle by an electric current, and showed how this phenomenon could be utilized for signalling at a distance.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity, Gas and Power.

OFFICIAL ORGAN OF THE PACIFIC COAST
ELECTRIC TRANSMISSION ASSOCIATION.

SUBSCRIPTION PAYABLE IN ADVANCE. TERMS—DOMESTIC, ONE DOLLAR
PER YEAR; FOREIGN, TWO DOLLARS PER YEAR.
FOR ADVERTISING RATES SEE PAGE XI.

The trade supplied by the San Francisco News Company.

EDITED AND PUBLISHED BY GEO. P. LOW.

Business Office, 516 COMMERCIAL ST.
Telephone, Steiner 623.

Address all communications to
Editorial Rooms, 427 TENTH AVE

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME V. NOVEMBER, 1897. NUMBER 2

EDITORIAL.

TRANSMISSION AT 30,000 VOLTS.

In discussing the proposed use of 33,000 volts on the transmission circuits of the Southern California Power Company, it was observed in those Columns some time since that "not a well grounded doubt has been expressed but that the undertaking will be crowned with success," and that the use of this high voltage for transmission purposes is now feasible is no longer a question of belief alone, for during a recent experimental run lasting three days, a potential as high as 30,000 volts was used continuously in actual work, under most trying climatic conditions. The experiment was made over the circuits of the Pioneer Electric Power Company of Ogden, under the direction of Mr. F. O. Blackwell, chief engineer of the power transmission department of the General Electric Company, and Mr. L. S. Boggs, electrical engineer of the Pioneer Company, from whom the following details of the experiments were derived.

A double pole line of three No. 1 wires extends from the powerhouse in Ogden Canon to Salt Lake City, a distance of 36½ miles. The transformers at the powerhouse and substations in Salt Lake City are connected in delta and are operated at a potential of approximately 15,000 volts at the powerhouse. For the purpose of experiment, however, these transformers were changed over from the delta to the star connections, and the electromotive force of the generator was also increased until a pressure of 30,000 volts was delivered to the line. At Salt Lake City the ends of the transmission lines was thus returned to the power house and delivered to a bank of three 250-kilowatt transformers which reduced the line pressure to 2,300 volts. This arrangement gave a transmission of seventy-three miles over which a load of 1,000 horse-power was delivered to the resistance vats at the power-house. The minimum potential delivered to line was 27,880 volts, during which 23,000 volts pressure was delivered from the return circuit at the power-house. The water rheostats consisted of three wooden tanks, each measuring eight feet in length by three feet in depth by four feet in width. These tanks were placed five feet apart and mounted each on three double petticoat, deep groove glass insulators. The electrodes consisted of 3-8th sheet steel of such size as to give one inch clearance on all sides.

The loss in the transmission was measured by wattmeters inserted in both ends of the lines so as to include that due to the transformers (which together amounted to 4 per cent) and the maximum loss thus derived was 9.9 per cent. "There was no loss of voltage to speak of," writes Mr. Blackwell, "the capacity of the line (the periodicity is 60 cycles) being sufficient to compensate for the potential [inductive (?)—Ed.] drop." Mr. Blackwell further states that not the slightest difficulty of any kind developed during the entire seventy-two hours covering the test. During the experiment for a period of a day there was also taken from the circuit at Salt Lake City, at a pressure of 24,000 volts, a load of 500 horse-power consumed in operating synchronous motors.

To continue to quote from Mr. Blackwell's letter: "During this period there was the worst possible weather—rain, fog and snow alternating, with no trouble whatever, and in addition there was a severe thunder and lightning all of one night, during which the lightning arresters discharged repeatedly without causing even a flicker in the light circuits."

At the conclusion of the experiments the transformers were changed over from "Y" to delta windings, and since then the plant has been running at 15,000 volts as originally designed.

THREE COLOSSAL GENERATORS.

The electrical press has recently described two large generators which are deserving of attention for their size and for other interesting features. The first is a three-phase dynamo, built by the General Electric Company for the Brooklyn Edison Company, and although it is rated at 1,500 kilowatts, it is stated that it is to be operated at 2,000 kilowatts output. It is of the revolving field type with forty poles; it is to be run at 75 revolutions per minute and will deliver a potential of 6,600 volts, and is to be direct driven by a four cylinder triple expansion engine.

The Brooklyn generator will deliver the high tension three-phase current to a system of conductors covering about 75 square miles of territory, and a large portion of the current will be transformed down to 375 volts and then, after passing through rotary converters, will be distributed at low voltage direct current to the three wire underground systems already receiving current from the stations now in operation. The remainder of the capacity of the generator will be utilized by synchronous motors operating arc machines, as well as for various power purposes.

More noteworthy still in several respects are the Stanley generators being installed in the power plant of the Chambly Manufacturing Company at Richelieu Village, about twenty-five miles distant from Montreal, where the Richelieu River falls through a long series of rapids. The Chambly power-house is an integral part of the dam and is being erected for a capacity of 22,000 horsepower. The generators are direct coupled to horizontal shaft turbines and are of the usual inductor type of the Stanley Electric Manufacturing Company, and they are of especial interest in that they are built to deliver 2,000 kilowatts of 60-cycle, two-phase current at a potential of 12,000 volts. The bulk of the power will be consumed by the central station of the Royal Electric Company of Montreal.

These two generators, together with the remarkable Westinghouse machines at Niagara Falls, may be accepted as the most noteworthy productions of the three largest companies engaged in the manufacture of polyphase generators for the transmission of power, and each machine has distinctive points of peculiar interest. The 5,000 horsepower Westinghouse generators at Niagara Falls exceed all others in point of size, but their output is but 2,200 volts. The Brooklyn three-phaser is remarkable in being the first large generator of the revolving field type, but its potential being only 6,600 volts, is practically the same as has been in use by the three-phasers of the Portland General Electric Company for nearly three years past. It so happens, however, that neither the Brooklyn or the Portland plants require the use of step up transformers, which eliminates the introduction of a loss of some consequence into the transmission, but were it advisable to transmit current at a higher potential, neither the Westinghouse or the General Electric generators, in the light of present accomplishments, embody the advantage of extreme high voltage output as convincingly as it is to be found in the Stanley machines now being installed in the Chambly plant. The delivering of high voltage is one of the especial adaptabilities of inductor type machines and so eminently is it suited for this that the revolving field generators of the Niagara and Brooklyn installations seem, in comparison, as but steps in the evolution of the perfect polyphase dynamo electric machine.

THE EFFICIENCY OF ILLUMINANTS.

Of the total energy supplied, a candle consumes 86 watts per candle; oil lamps, 57 watts; butterfly gas burner, 93 watts; incandescent lamp, 3.5 watts; arc lamp, 0.8 watts. Thus, if gas is used in a gas engine having an efficiency of 20 per cent, it will produce about five times more light from incandescent lamps than if burned direct in butterfly jets.—American Electrician.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

A NUMBER WITHOUT ILLUSTRATIONS.

A profusely illustrated magazine, if brought out in a manner in keeping with the highest state of the art, is pleasing to the eye or may be necessary to a clear conception of a principle or situation, but sometimes hard information reciting experiences and convictions are more indispensible and these can only be set forth to advantage in the judicious combination of solid type, printer's ink, and good paper.

Of such is the present issue of The Journal of Electricity, and while its change in appearance may occasion comment, it certainly can not be adverse when it is known that those who prefer a liberal display of engravings are assured that their absence from this number does not indicate a permanent departure from the use of the usual illustrations that have become so prominent a feature of the style of the paper.

WHEELS WITHIN WHEELS.

The San Gabriel Power Company has awarded the contract for the electrical machinery for the installation of its proposed 1,500 horsepower transmission plant, to the Westinghouse Electric & Manufacturing Company, and now speculation is rife as to whether the Westinghouse Company will find it to be the fiat of the Board of Control of the General Electric-Westinghouse "patent pool" that the contract must be turned over to the General Electric Company, as is said to have been done in the case of the contract for the Los Angeles equipment of the Southern California Power Company.

SUCCESS IN ADVERTISING.

One of the most pleasing of the many attractive advertisements appearing in the street railway periodicals is that of the Standard Air-Brake Company. It is always new, always catchy and it is safe to say that when once read, it is read each month, even by the disinterested. So catchy is its tout ensemeble that one recognizes that the concern appreciates every detail of the fine art of advertising so thoroughly that he who has eyes is compelled to read, unless he be a dotard.

No wide-awake business man will pass unheeded the wise suggestion contained in a recent "ad" of the Standard Air-Brake Company, which, in discussing advertisements, observed:

"As a matter of fact, it's rather difficult to keep up a supply of fresh advertisements, when a solitary article like an air brake is the only thing to put before the public. But somehow we have to do it. Have to, because just as soon as we stop varying our ods, there's an abatement of inquiries.

"And it's inquiries we are after! Every man who made an exhibit at Niagara Falls, and every man who invokes the aid of the press, does so with a view to getting inquiries. We all know that these are stepping stones to actual transactions."

Without doubt the advertisement which pays best is the one that is always fresh, crisp and to the point. It is well that the "ad" should always hold a certain space in the paper, but above all it should contain new matter so attractively presented that the reader will read the announcement as habitually as he does his morning paper. Indeed, did the morning papers contain the same matter, word for word and line for line, day after day and month after month, would they be read? Their variety, freshness and newsiness make them invaluable, and as with newspapers, so with advertisements.

THERE'S NO EXPERIMENT ABOUT IT.

On page 722 of the London "Electrician" for September 24th last, appears the following statement that, in the light of present knowledge regarding electrical transmission of power, and considering the source of the publication, is surprising:

> "Mr. L. B. Stillwell, electrical director of Niagara Falls Power Company, says the transmission of 1,000 horsepower a distance of 26 miles is still an experiment, and until he has had actual experience in transmitting a block of 5,000 or 10,000 horsepower that distance, he has no opinion to express upon its efficiency."

The portion of the above relative to efficiency is rational, but the belief that it could not be the opinion of so eminent an engineer as Mr. Stillwell that "the transmission of 1,000 horsepower a distance of 26 miles is still an experiment," led the writer to call the paragraph to the attention of that gentleman and to solicit an expression of his views on the point for publication.

In reply, Mr. Stillwell wrote to The Journal of Electricity under date of October 18, 1897:

> "The paragraph appearing in the London "Electrician" for September 24, 1897, must have been based upon a statement which I made in a letter written last July in reply to an inquiry for a large block of power. The inquiry came from a city at a very considerable distance from our power plant—a distance very much greater than 26 miles—and referring to the copy of my letter I find the following:
>
> "The Niagara Falls Power Company is now transmitting 1,000 horsepower from Niagara Falls to the City of Buffalo—a distance of 26 miles— and we are gaining valuable experience in connection with this transmission. By January 1st, it is expected that 10,000 horsepower will be transmitted to that city over our lines, but until we have had actual experience in transmitting a block of 5,000 or 10,000 horsepower and have made complete tests of losses, etc., we shall not be ready to give positive information in regard to a proposed transmission over the much greater distance involved in conveying power to your city."
>
> "The word 'experiment' was not used in my letter."

It is generous to opine that the paragraph quoted was "run in" on our esteemed London contemporary during a period when the editor slumbered and the office boy dominated the sanctum to the satisfaction of his own prankish humor.

THE ENGINEERING OF THE BLUE LAKES PLANT.

"The Electrical World," (Vol. XXX, No. 20) reprints a complete abstract of the description of the electric transmission plant of the Blue Lakes Water Company, appearing in the last issue of this publication, and in commenting on the installation, editorially observes:

> In the plant of the Blue Lakes Water Power Company are two notable departures from customary engineering practice. The first is the complete absence of receivers, air-cushion chambers or relief valves of any kind on the pipe-line system. As the pipe line is some 3200 feet long, and has normally a head of 1000 feet at its lower end, with a velocity of flow of several hundred feet a minute when running at full capacity, the risk of omitting all relief measures would seem to be great. The engineer in charge has, however, evidently considered that prevention is better than cure, and instead of providing measures for relieving water hammer which depend for their action on the hammer itself, he has so designed his gates that the water cannot be shut off with sufficient rapidity to cause ramming. This necessarily forbids the use of governors controlling the flow of water, and the governors to be installed will regulate by diverting the stream from the wheel by means of hoods over the nozzles.
>
> The other innovation is the use of direct-connected impulse wheels and generators, the shafts of which are hung on only two bearings the waterwheels and the flywheels being overhung at either end. The amost universal practice of underhanging such heavy wheels running at high speeds makes this a rather daring experiment. Considered theoretically, however, the overhung arrangement would seem to have considerable advantages over a shaft with similar loads supported by two bearings, one at either end, in that the shaft resists the bending stresses as does a beam, the overhanging ends acting as cantilevers and tending to balance loads applied on the underhung portion. Comparing the method used at Blue Lake City, with machines using three bearings, it must be remembered that dynamo shafts are necessarily very stiff, due to the enormous bending forces set up in case of any eccentricity of the armature in the field of force. To distribute the load on such a stiff shaft uniformly on three bearings the latter must be lined up with almost mathematical accuracy, a difficult thing to accomplish in some instances. Any deviation from perfect trueness in the shaft will also cause great vibratory strains in a shaft supported stiffly at three points. The lining up of two bearings is obviously perfect under all conditions, the use of spherically mounted brasses allowing also for any lack of trueness in the shaft. The overhanging weights on the ends of these shafts should give no more trouble, if perfectly balanced, in motion than in rest. To be sure, in addition to the weight of the water wheel there is added the force of the jets striking the buckets, but this force undoubtedly introduces strains much smaller than those in the crank shafts of an engine with overhung cranks.

THE NEW PROBLEM IN TRANSPORTATION.

"Managing officers of steam railroads have been watching the inroads of the electric lines with great concern, and it is evident that prompt action must be taken or most of the suburban business will be transferred to the trolly lines," observes the American Engineer Car Builder and Railroad Journal in discussing the formidable competition that the development of electric traction has given rise to. Continuing, it points out that "ten years ago there was almost no electric traction. Now in the United States alone there is a trackage of nearly 14,000 miles. The increase in revenues is not less remarkable, for we are told by Mr. Wm. J. Clark that a road 30 miles long, without increasing its trackage or making any other change except to substitute electric for horse traction, has increased its dividends from $60,000 in 1886 to $800,000 in 1896.

"The steam roads desire not only to offset the competition of the electric roads; they also want to derive the benefits now enjoyed by the trolly lines as the fruits of better service. One reason why it has been impossible to compare the cost of operation of steam and electric traction on the same road is the tendency for the electric equipment to stimulate travel and increase the volume of business. This is clearly shown by the reports of the increase in travel between Hartford, New Britain and Berlin over the electric line of the New England Railroad. The last year of the operation of steam on this line showed an average of 750 passengers per day.

"The number carried under the new plan at once jumped to high figures; the number for the first week, ending May 30, was 27,507, and for the following week 31,513. In the next week it was 20,000. These figures do not represent ordinary conditions because of the novelty of the line, which had a great influence on the amount of travel at first. The smallest number for a week has been 14,502, and for the week ending October 3 the number was 15,145, which may be taken as fairly representing the average conditions. The increase is due to several influences which are too well understood to require enumeration here."

Judging from the remaining portions of the editorial quoted, it does not appear that the steam lines will forego their long-loved steam locomotive for the electric motor without a serious effort to demonstrate that the steam dummy may be developed and perfected so that it will fulfill the conditions of the new problem as satisfactorily as is done by electricity. The fact of high economy in operation by electric traction seems to be generally accepted in railroad circles, but the deterrent to equipping existing steam lines with electricity lies in the financial burden of a change of power. For this reason, therefore, it appears to be the conclusion of many who are well posted in steam railway engineering that the solution of the problem will be found more readily in an adherance to the old method than in the adoption of the new one.

That this belief will bring forth adverse criticism, is not to be doubted and so far as the public is concerned, given two routes of travel in a modern electric line and in a rejuvenated steam dummy road, (ycleped "the smoky line") and it will not be slow to evidence its preference for the former. On the other hand, probably the acme of development of steam motors is to be found on the Manhattan elevated road, concerning the service of which the public never ceases to complain. Then again, the cost of an electric equipment is not so very great, considering its high efficiency and its popularity, and considering the low efficiency and the undetermined cost of experimenting upon the perfection of the steam dummy.

It is wisdom to go slow and be sure in the adoption of any revolutionizing methods in any industry of great magnitude, but the trend of the times points to the adoption of electricity on steam lines at an early date as being inevitable.

Fraternal

THE TRANSMISSION CONVENTION AT SACRAMENTO.

The second quarterly convention of the Pacific Coast Electric Transmission Association, was held in Sacramento on October 20-21, last and proved to be of unusual interest. The two themes for special consideration were "Protection Against Lightning," and "Hydraulic Problems," both of which elicited papers and discussions of great merit. The papers read are reproduced elsewhere in this issue, while the discussions will appear in the ensuing number.

The meetings were held in the parlors of the Golden Eagle Hotel on the evenings of the dates given and the second day of the session was devoted to an inspection of the extensive system of the Sacramento Electric, Gas and Railway Company, including a visit to the power house at Folsom. Mr. C. P. Gilbert, President of the Association and Manager of the Company, acted as host and despite the inclement weather, those present enjoyed a most agreeable and profitable day.

The next convention of the association will be held in San Francisco during the two days beginning February 20, 1898.

"ON DIT."

"Your paper is highly appreciated," writes Mr. E. A. Squire, of Repressa, Cal.

"Allow us to compliment you on your fine editions. You deserve patronage."—Big Creek Power Company, Santa Cruz, Cal.

MATRIMONIAL.

Cards are out announcing the marriage of Mr. Ross Morgan to Miss Elizabeth Bodwell, in Lakeville, Cal., on October 13th last.

Though Mr. Morgan has long been well and favorably known in civil and municipal engineering throughout California, he has but recently come into prominence before the electrical engineering interests and the means of doing so were through his association on the staff of engineers engaged in the construction of the electrical transmission plant of the Blue Lakes Water Company. Mr. Morgan is one whose sincerity and geniality and ability makes friends for him on every hand and already he has won myriads of electrical friends who join the Journal of Electricity in wishing the newly mated couple the fullest measure of happiness and prosperity. The bride is the accomplished daughter of Mr. and Mrs C. A. Bodwell, of Lakeville.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

A SUCCESSFUL ALTERNATING ARC LAMP.

The "Puritan" arc lamp during the past two years has been very widely adopted by central stations, as it embodies a number of features which heretofore have not been overcome in arc lighting. This type of lamp seems to obviate certain faults and failings of the old open arc. A prominent electrician who has been closely identified with some of the best construction work in America remarked the other day when looking at one of these lamps. "The difficulties encountered in the application of arc lamps to alternating-current circuits have largely been overcome since the present form of lamp has been on the market, and unquestionably the art of electric lighting has been more affected by these recent improvements than is appreciated by those who have considered this question."

The Puritan lamp, manufactured by the Puritan Electric Company of New York and Boston, is designed to burn upon a secondary voltage anywhere between 90 and 120 volts, and taking six amperes of current, the total wattage of the lamp will range between 400 and 450, of which all but 25 watts are actually consumed at the arc in producing light. The mechanism is simple and not easily deranged, and 100 hours' life is obtained from the seven and one-half inches by one-half inch carbons, the upper and lower carbon being of the same length.

It is adaptable for use for both inside and outside lighting, and the humming and buzzing common to the old alternating arc has been entirely eliminated, making it unobjectionable in even the most confined quarters, while its short length makes it adaptable to the lowest ceilings.

No special transformers or economy coils are necessary, and the lamp is entirely self-contained and burns in multiple.

A CHAPTER ON MICANITE.

Micanite is made of pure India sheet mica, joined together with a cement of very high resistance and it is recognized as the standard electric insulation. It can be shaped into almost any form desired and in a catalogue issued by the Mica Insulation Company of New York and San Francisco, they describe some of the purposes to which it has been put. Micanite is in use by the largest manufacturers of electric machinery, and by the electric street railways, and has given universal satisfaction. It is abreast with the times and is the only material adaptable to the high potential insulators of the present day.

On account of its high insulating qualities, Micanite can be used in places where inferior insulators would not be practicable, because of the thickness required by low grade materials to insulate.

It does not absorb oil or moisture—a great fault of inferior insulators—and its mechanical and electrical durability is unexcelled. It is equal in efficiency to India sheet mica and can be furnished in almost any form desired, thus effecting a great saving over the use of mica, when the labor entailed and the waste in mica are taken into consideration.

Mr. Franklin Brooks of New York, who is manager of the Mica Insulator Company, was in India recently and effected a combination whereby the Mica Insulator Company is in a position to furnish mica cheaper than any other concern in the United States. Moreover, in dealings with them, customers reach first hands and do not have to pay middle men's commissions. A large stock is carried in San Francisco, from which point all orders can be filled with dispatch.

The Mica Insulator Company is now placing on the market an insulating compound for the insulation and coating of all parts of motors, generators, armatures, field magnets, wires, cables, transformers, overhead line construction, arc lamps and switch boards, as well as on all bare metal surfaces. On cloth, paper, fuller board, etc., it has no equal. It is non-corrosive, and stands high temperature, it is impervious to moisture, has NO OFFENSIVE ODOR, is of full body and can be reduced to any desired density. Its price is very low.

TABLE OF CONTENTS.

Illustrated articles are indicated by an asterisk (*)

Transmission

Page.
Lightning on Transmission Lines, by Theo. E. Theberath, M. E. 35
Lightning at Sacramento, by C. W. Hutton 38
Lightning in Nevada County, by E. J. De Sabla, Jr. 40
Insulators for Transmission Lines, by Jno. Martin .. 41

Editorial

Transmission at 30,000 Volts 44
Three Colossal Generators 44
A Number Without Illustrations 45
Wheels Within Wheels 45
Success in Advertising 45
There's No Experiment About It 46
The Engineering of the Blue Lakes Plant 46
The New Problem in Transportation 46

Miscellany

Hydraulic Problems, by W. Stuart-Smith 29
Water Wheel Regulation, by S. N. Knight 32
The Electric Transmission Association at Sacramento 47
The Infancy of the Telegraph 43
Personal 42
Matrimonial 47
*A Successful Alternating Arc Lamp 48
A Chapter on Micanite 48

The Journal of Electricity

Vol. V. DECEMBER, 1897. No. 3

Some Station Wrinkles.

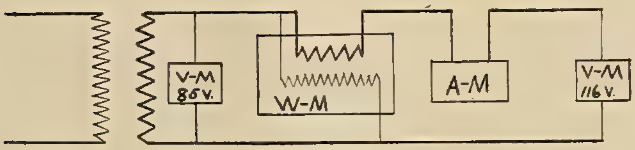
MANY, many times, the central station engineer novel expedient, in order that the rigors of enforced economy may be circumvented, or that forced economy may be circumverted, or that liability of trouble may be averted, or that some detail of operation may be facilitated, or that some little saving in running expenses may be credited, or, in brief, that the general efficiency and reliability of his plant may be increased. It is every manager's endeavor to "round off the corners" of his operating expense sheet—but when he has not the money with which to make advisable changes, he must put his wits to work, and while, oft-times, he is baffled in his endeavor to solve a problem without filing a requisition for expensive apparatus, it is more often that his ingenuity saves the day and provides a means at once simple, cheap and effective. That suggestions may be extended from experiences of different plants throughout the West is the object of this article.

Climbing Mount Lowe.

Reference to problems that arise in station practices recalls instances wherein seemingly uncrackable nuts have arisen, and the two cases about to be cited will afford food for cogitation, until their further discussion appears in an early issue of this publication. Meanwhile, the editor will be glad to receive from readers, communications embodying ideas or proposed solutions of the problems.

The first case is that of the load line of the San Joaquin Electric Co. at Fresno, Cal., the peculiarity of which is that between 7 and 8 o'clock each morning, the power house and sub-station load lines cross, that is the latter is from 50 kw. to 75 kw. in excess of the power house load. The transmission line is 35 miles long, the initial voltage is 11,300, the circuit is No. 3 B. & S., the sub-station load consists of about 8,000 incandescent lights and 1,000 h. p. in power service, about equally divided between motors of the synchronous and induction types. The readings are volt-amperes, as the stations are not provided with indicating or recording wattmeters. Query—Why this habitual crossing of the load lines?

In the second case the query is based on an anomaly in a voltmeter reading, and the experiment was performed at the laboratory of the Chief Electrician of the City of Alameda, Cal. The leakage of a twenty-light transformer was under test, the connections being as per diagram above, where with 2,320 volts primary, 116 volts is obtained from the secondary. These are the normal voltages of the plant, the periodicity being 7,200 alternations per minute. A standard Weston indicating wattmeter, a Whitney ammeter, and a Weston alternating current voltmeter were cut in the secondary, as shown, the circuit consisting of about 50 feet of No. 14 cotton covered flexible cord. Under these conditions, the wattmeter indicated 30 watts to be at the transformer leakage, the ampereage being so light as not to register on the amperemeter. In the final experiment, the Weston voltmeter was cut in across the leads at the transformer. The lamps in the building remained at proper voltage, showing no disturbance in the normal condition, but the Weston voltmeter connected, as indicated in diagram to the terminals of the transformer under test, gave a reading of but 85 volts! By a chance suggestion, the voltmeter was then placed across the flexible cord at the end farthest from the transformer, when it showed the full potential of 116 volts to be on the circuit. This situation was incomprehensible and both readings were taken three times over, with the same results. Query: What occasions this false potential reading?



An Anomalous Voltmeter Reading.

Part 1

HOW MOUNT LOWE IS CLIMBED.

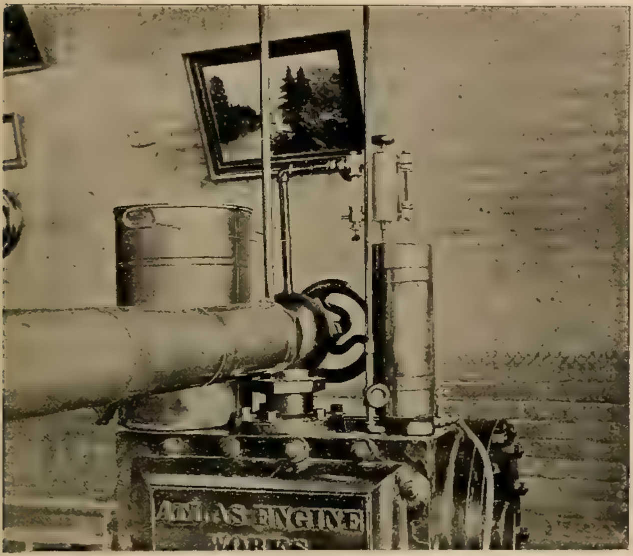
The means by which the ubiquitous trolley takes passengers, in a ride of an hour or so, from the orange groves of Pasadena, or more properly Altadena, up thousands of feet to the snows of Mount Lowe, in Southern California, are such as would tend to confirm, in the engineering mind at least, the extravagent stories that have been soberly told anent the wildness and wooliness of the West. The illustration appearing on page 49 shows the electric car, or chariot, as it is termed, and incidentally gives visual demonstration that the road is a mountain railway indeed.

The complication of the power plant, however, presents the most interesting engineering feature of the system. It is in three distinct divisions, two of which, each contain a direct current electric motor, two gasoline engines, and a railway generator, while at Rubio Canyon, an intermediate point, is a tangential water wheel and constant potential generator, used in conjunction with the electric motors in the power houses for starting the gasoline engines, and also for furnishing current for operating the electric motor that hauls the car by cable up the incline at Rubio Canyon.

The modus operandi of the system will convey a better idea of its arrangement: The amount of water available for power purposes is limited and even sufficient to operate the plant as laid out is obtained only by impounding. The use of gasoline engines was determined upon as affording the cheapest power and four were installed—two at the Altadena power house at the foot of the mountain, and two at Echo Mountain Hotel, about midway up the mountain. But three or four trips are made daily and as there is but one car on each of the two divisions, and as these cars connect, only one section is operated at a time. The first section extends from Altadena to the foot of the incline in Rubio Canyon, where the water wheel plant is located. At the head of the incline is the hotel, dimly shown in the lower left hand corner of the illustration given. Here is a duplicate of the gas engine and dynamo plant at Altadena and from here the "chariot," as the electric car is called, takes the tourist on up to the summit of Mount Lowe. The beauty and grandeur of the ride makes it a never-to-be-forgotten one.

A Home-made Oil Filter.

When all is ready for the ascent, the attendant in the station at Altadena telephones that fact to the water wheel station at the foot of the incline and the water wheel and generator are started, which charges the trolley wire, from which is operated an Edison bi-polar motor in the Altadena power house. This motor is started by means of a barrel filled with salt water, and a sash weight, together forming an improvised starting box. Once under way, the motor drives a jack shaft, to which are belted two gasoline engines through clutch pulleys. When the shaft is up to speed, the clutch pulley of the first engine is thrown in and after the engine has pumped up sufficient pressure for running, it is started, using a primary battery for ignition from the spark coil. After the first gasoline engine is in operation, the attendant throws the motor belt from off the jack shaft with a stick, then starts from the gasoline engine a little low voltage direct current generator for the spark coil, thereby cutting out the primary battery. The attendant then starts the second engine from the first one through the jack shaft and its clutch pulley and then telephones the power house at Rubio Canyon to shut down the water wheel. He next throws the clutch that starts a Westinghouse railway generator of an old style that resembles a Waterhouse arc machine, soon after which the car may commence its 25-minute climb up the lower section of the road. As soon as the car arrives at its destination, the Altadena power house is notified by telephone and the gasoline engines are shut down until the time arrives for the next trip, some four hours later.



THE NOBLE LUBRICATOR RESERVOIR.

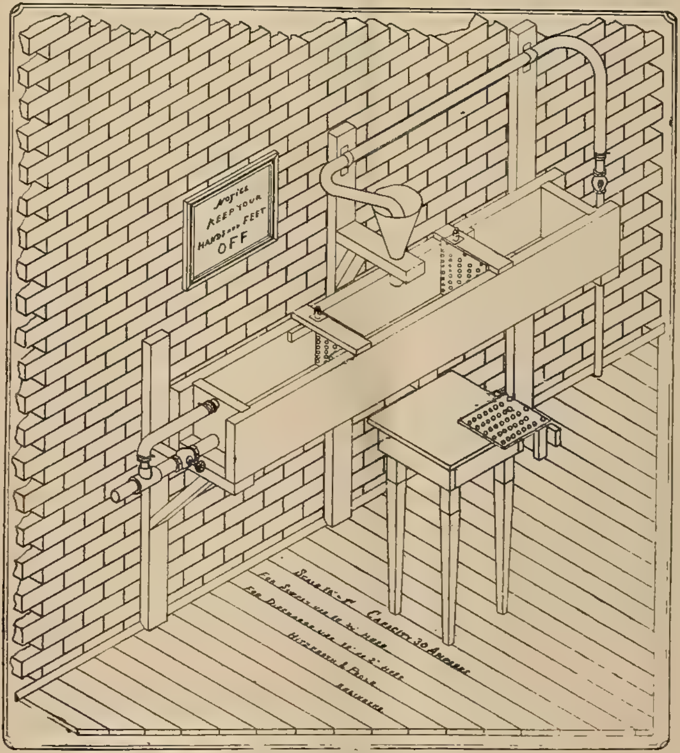
This takes the car to the foot of the incline, where the passengers change to a special cable car, and when all is ready, the water wheel in Rubio Canyon is again started and the generator it drives furnishes current to an Electrical Engineering Company's motor which hauls the car to Echo Mountain Hotel. At this point there is a power house equipment that is practically a duplicate of that at Altadena, and when the tourists have changed cars for the final climb, the gas engines in the Echo Mountain station are started by an electric motor taking power from the water wheel plant precisely as was done at Altadena, and after the plant is in operation, the water wheel plant is shut down as before, and the chariot ascends to the summit. The descent is made in safety by braking—as the maximum grades vary from six to seven per cent.

It can not be stated that a description of the Mount Lowe installation is given with any other idea in mind than that of the novelty it presents.

Part ii

THE SAVING OF OIL.

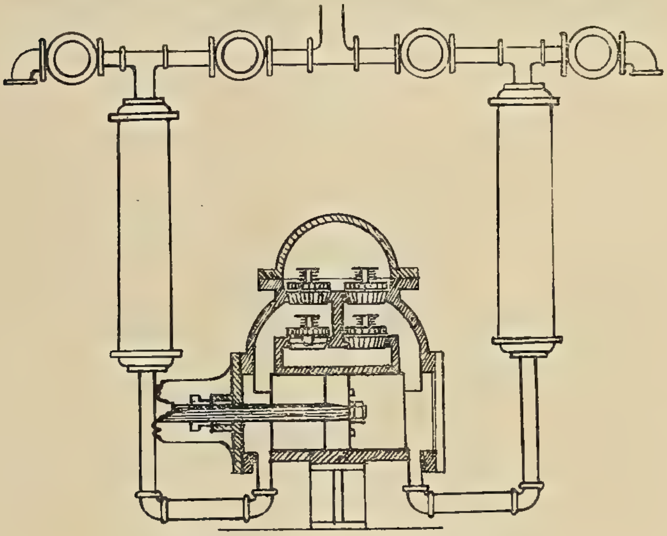
Every station has its peculiarities regarding the using, saving, purifying, and re-using of lubricating oil, but many appreciate at too late a period that the fullest saving of oil becomes seriously embarrassed when engines are mounted on plain concrete foundations. Painting foundations renders them non-absorptive, hence economy in oil is effected to the greatest advantage in stations having the engine foundations so coated that such oil as accumulates on them may be gathered and filtered, together with that taken from the drip pans. But the route from drip pan and waste bunch to the filter forms an oft-told tale, though seldom is it recorded that a thousand horse power plant has consumed eight gallons of lubricating oil for each night's run. Such was the record of the Electric Improvement Company of San Jose, until about two years ago, when the incumbent, Mr. George J. Johnson, took charge of the engine room. Mr. Johnson was formerly a railroad engineer, where the best record of economy was not only recognized by a prize, but became a matter of great pride. His attention was first directed to saving oil in the San Jose station and through the home-made appliances about to be described, instead of using eight gallons of oil per day, a



A 7000-VOLT WATER RHEOSTAT.

barrel of 52½ gals. of the same oil was made to run the plant for seven months. This saving was not effected through the scant use of oil, for nineteen quarts of oil is filtered daily, there being added to this filtration each day enough new oil to restore the loss in quantity and body.

The oil caught in the drip pans, together with that which is wrung out of used waste by an ordinary clothes wringer, is run into a receiver, consisting of an oil barrel with a gauge glass in the side. It is in this tank that grit settles, and the oil which rises to the surface is taken to two filters, practically identical in external appearance and one of which is illustrated on page 50. The first of these consists of a series of strainers of varying degrees of fineness, and the second, which is called the refiner, differs from the first only in that its filters or strainers are of finer and closer materials, such as flannel or other woolen fabrics. In each filter the oil is washed by passing through water, and after passing through this course, the oil is as clean as when new, though of slightly less body. The outfit did not cost $25.00, yet it and painstaking wiping have effected a saving of nearly double that amount each month over the old method.


Pumping Air by Water Pistons.

A new use for the steam separator has been devised by Mr. I. O. Crosscup, engineer for the building of the San Francisco Savings Union. The installation consists of hydraulic elevator, isolated electric lighting and steam heating plants and the novelty consists in the insertion of a Stratton steam separator in the exhaust line before entering the steam heating system. The idea of this is not to furnish dry steam to the radiators, but to wring the oil from the exhaust steam, which it does very effectually. A two-fold benefit results from this: namely, the efficiency and utility of the system is not seriously impaired by precipitations from the use of wet oil-soaked steam and, second, oil is saved which would otherwise be lost in the heating system, or be exhausted into the atmosphere.

In Mr. Crosscup's installation the separator drains into an iron tank with gauge glass and containing globe valves and piping for draining off the oil and water respectively. The oil is then clarified by hot filtration and used over again, and so thorough is the economy in the use of oil carried, that the total oil item amounts to but a few dollars yearly.

Some engineers have reason to complain of the small lubricators with which their engines are supplied, but Mr. Frank Noble, chief engineer of the Sanger Lumber Co., of Sanger, Cal., has placed a supplementary reservoir to a lubricator, as shown in the cut on page 51. In this, the supplemental reservoir may consist of iron pipe, capped, or any other suitable chamber, from the top of which a short nipple extends into the orifice originally filled by the condensation pipe of the lubricator. The condensation pipe is now extended down to the bottom of the supplemental reservoir, from which also extends a drain pipe for carrying off the drain in filling the lubricator. The apparatus is then used precisely as though it were a simple lubricator, the only difference being that while it takes longer in filling, it runs without refilling a correspondingly longer time.

Part iii

WATER RHEOSTATS.

There is a time in the history of every station, and there are many times in the history of some stations, when it becomes necessary to load both prime movers and generators up to full capacity; and it is seldom that commercial conditions are such as to permit the throwing of regular service on to the machine so as to obtain a full load for a given period. In other instances, it is necessary that the load thrown on generators should be of a non-inductive nature. Originally resistance racks supporting spirals of iron wire were used, but these were cumbersome, expensive and unsatisfactory, the latter condition being mainly due to the fact that on heating, the wire would soften, which would bring the turns of the spirals into contact, causing short circuiting, and so forming an unreliable, if not dangerous, combination. Now, however, the eminent suitability of water rheostats is universally recognised for any amount of load or any voltage, but the fact remains that the proper methods of constructing and using these appliances are not well understood.

Pure water is of very high resistance and for this reason it is necessary, in absorbing energy under low voltages, to increase its conductivity by the addition of common salt, or preferably, sulphate of sodium. Chloride of sodium, or common salt, when in solution, possesses the property common to carbon in that its conductivity increases with the temperature, and this fact renders its solution unsuitable as an electrolyte for water rheostats where exact measurements are necessary. To illustrate further, if a rheostat contains a fixed solution of sodium chloride and if the electrodes are rigidly separated a fixed distance, the ampereage which the rheostat will absorb, will increase directly with the rise in the temperature of the water until the boiling point is reached,—and it is never advisable to permit the water in the rheostat to reach the boiling point. With sulphate of sodium, however, this property exists in a much less marked degree, for after the tank has been fairly well warmed up, the variations in the resistance of the electrolyte from fluctuations in load, becomes a negligible factor. Foaming does not occur in properly manipulated rheostats when either common salt or sulphate of soda are used, but almost invariably becomes an annoyance when barrels are impressed into service, doubtless for the reason that oil barrels are generally used and the oil remaining in them saponifies with the soda.

An instance illustrating the use of water rheostats of the nature described was that occurring during the test of the power plant at Bakersfield, Cal. The object of the experiment was to determine the efficiency of the set of Girard wheels that are direct coupled to a 450 kilowatt, 500-volt, three-phase generator, as illustrated on page 91 of this Journal for August last (Vol. IV., No. 5). The water rheostats consisted of three separate redwood tanks, each measuring 4x4x6 feet in size, and each containing two sheet iron electrodes of such size as to give five inches in the clear when suspended in the tanks. Three of the six electrodes, one from each tank, were coupled together in short circuit, while the three legs from the three-phase generator were each taken to the remaining electrode of its respective tank. Each phase, therefore, was in this manner provided with an independent rheostat which was capable of absorbing 150 kilowatts. The amount of load on each phase was regulated by varying the separation between the electrodes of its particular tank, and so well proportioned was the amount of sulphate of soda placed in the tank that the rheostats would carry a load of 500 horse power for three hours or more without boiling.

It should be emphasized that it is unnecessary to increase the conductivity of water except for potentials below 1,000 volts, and that the absorbing of energy under higher potential, is in some respects a more simple matter than at low potentials. At high potentials the conductivity of the water is not increased or altered in any way and the amount of the resistance is gauged only by varying the separation between the electrodes. The operation of a water rheostat absorbing energy under high potential is well illustrated in the method pursued in the experiment made over the transmission plant of the Pioneer Electric Power Co., as editorially referred to, in these columns last month (page 44). The water rheostats for this test were arranged precisely as in the Bakersfield test, the only difference being that each of the three tanks measured eight feet in length by three feet in depth by four feet in width, and was mounted on three double petticoat, deep groove glass insulators. The electrodes consisted of three-eighths inch sheet steel of such size as to give one inch clearance on all sides. Each tank, moreover, absorbed 250 kilowatts at 2,300 volts instead of 150 kilowatts at 500 volts, as in the Bakersfield experiment.

The distinguishing feature in the use of water rheostats for high potentials, lies in the advisability of a constant circulation of water through the tank in order to keep the temperature as low as possible, and to a minor degree, to wash off the bubbles of oxygen and hydrogen from the electrodes, so that the resistance of the electrolyte may not be increased thereby. This circulation is accomplished by running a stream of water into the tank through a hose, as obviously to carry the water to the tank through an iron pipe would ground the electrolyte,—and grounds are never desirable. The overflow or waste from the tank is also carried off through a hose, the length of which, if the water is reasonably pure, and if the hose is of less than an inch in diameter, need not be more than twelve or fifteen feet for potentials up to 2,500 volts. The water used in the test at the Pioneer plant was of unusual purity, being from the snows of the Wasatch range, a few miles above the plant, and so great was its resistance that no leakage to ground could be observed on holding the finger in the stream running from the outlet of the tank.

The outline drawing on page 51 illustrates the design of water rheostat due to Messrs. Hitzeroth and Poole, and as used by the San Francisco Gas & Electric Co. for testing 2,200 volt alternators and 10 ampere arc machines of various capacities up to 7,000 volts. The device is very simple, consisting of a long wooden box, or trough, closed at the ends, and painted inside and out with P. & B. paint. In this trough are supported two electrodes of plate carbon. These electrodes each measure ten inches square, by one-half an inch in thickness, and are each perforated with forty or fifty one-half inch holes to facilitate the circulation of water. Fresh water from the city main is run into the tank continuously during use, through about twelve feet of one-half inch rubber hose, and the waste water is let to the sewer through about the same length of hose, no grounding resulting from the arrangement. With this rheostat, as with all others, the conductivity of the water varies with its height and temperature, but when it is filled to within two inches of the top and after it has reached a practically fixed temperature, its resistance is such that with a potential of 2,300 volts, a separation of 10¼ inches between the carbon plates gives an approximate current of 20 amperes; 15½ inches gives approximately 15 amperes and 19¾ inches gives approximately 10 amperes.

Part iv

COMPRESSED AIR.

If even a partial realization was had of the manifold uses to which compressed air could be put as a cleansing agent in and about electric light stations, the system would be installed in every plant regardless of its size. For cleaning armatures, fields or bus bars, or for blowing out arc lamps, transformers or switchboard appliances, it is simply indispensable, and the saving that it effects from armature burnouts alone by reason of the facilities that it extends for always keeping them scrupulously clear from any dust or foreign particles that may chafe and eventually result in short circuiting and burn out, alone demonstrates that it is the safest insurance that it is possible to have against trouble.

The larger stations may easily afford the cost of a complete compressor plant, the best efficiency in the operation of which will be attained by driving the compressor from an electric motor rather than by an independent steam engine. The smaller stations may now find on the market small compressors that will satisfactorily fill every requirement and these may be driven by belting wherever it may be convenient to do so. Those stations, however, which look upon the installation of an air compressor as a luxury rather than as a necessity, yet which feel that it may be of some slight utility, will find a fairly satisfactory substitute in the novel air compressing apparatus in use by the Pioneer Electric Light Works of Sanger, Cal. The outfit, including receiver, should not cost more than $20.00, if it be installed by the engineer during odd moments, and if he uses such materials in its construction as are always to be found about an electric lighting plant.

Briefly described and referring to the accompanying outline drawing on page 52, the apparatus consists of two upright columns in open connection by suitable pipe fittings to the front and rear chambers of the plunger of one side of a duplex pump. The fittings may be attached to the pump through the holes that are tapped in to the bottom of the pump chambers for the pet cocks that are sometimes used for draining the chambers, and it is advisable that the fittings be made each through an angle valve so that the air pump may be closed down readily. To avoid confusion, however, these angle valves are omitted from the sketch.

Inasmuch as the passage from each side of the plunger to the upright columns is always free while the air pump is in operation, it is clear that as the plunger makes its stroke from end to end, the level of water in the columns will rise and fall in step with the stroke of the plunger, providing the upper ends of the columns are unobstructed. If, however, the upper ends of the columns are obstructed, such air as may be in them will be alternately compressed or rarified according to whether the level of water in the column rises or falls. The levels of water in the columns are, therefore, constantly changing, hence the water therein becomes a liquid piston, oscillating in step with the pump plunger and, in fact, it transmits the motion and energy of the piston from the plunger chamber to the upright columns, so far as the capacity of the fittings admit.

But instead of being free and unobstructed, the upper ends of the columns are provided with four check valves, shown in circular form in the drawing. These are connected as in an ordinary single acting plunger pump so that when the level of the water in the left-hand column, for instance, falls, the check valve at the extreme left, opens, admitting air to the vacuum caused by the descent of the water piston, while the adjoining check valve to the left of the center closes. On the reverse of the stroke, the check valves naturally reverse their positions, the first closing and the latter opening, thus affording a passage for the relief of the compressed air, which has been compressed by the rise of the water piston. The side outlet of the center tee passes through a globe or gate valve whence the air is led to any suitable receiver—an ordinary fifty gallon house boiler for water-back service answers admirably.

The arrangement may be attached to the boiler feed pump, which will be affected by it only to the extent of diminishing its pumping capacity. At first thought it may appear that such connection will be impossible, for the reason that there is nothing to prevent the atmosphere from entering the suction chamber through the open check valves and upright columns, but in actual use this does not occur if the pipe fittings are sufficiently small and if the angle valves previously referred to are never opened until the pump is in full and proper operation. The tendency of the arrangement is of course to afford an ingress of air to the suction chamber, but the loss of water from the columns in this way by atmospheric pressure is much less than is the increase of water therein from the excess pressure of the up-stroke, which may be at more than double atmospheric pressure. It is difficult to so design and regulate the apparatus so that no water will be thrown over into the receiver, but the quantity of this water is not great and is easily taken care of by occasionally draining the receiver. Pipe fitters know that steam joints must be made tight; that water is more difficult to confine in piping than steam, and that compressed air is the hardest of all to restrain, hence the necessity for the most careful workmanship, particularly in the matter of check valves.

The Cheapest That "Ever Happened."

No attempt has been made in the cut to draw the parts to scale, but the apparatus, when propely proportioned and carefully handled, will give satisfactory service for air pressures up to forty pounds per square inch, which will answer for the purposes to which it is to be put. It will serve its purpose well, however, if it does nothing more than convince the station manager that compressed air is an indispensable commodity to every economically-run electric station, and when he has this conviction, he will install a regularly built compressor of recognized worth—they do not cost much—and will do away with the make-shift device here described.

Part v

MISCELLANEOUS.

The reluctance which American central station engineers have to the coupling of alternators in parallel, and the growing necessity for doing away with the great multiplicity of small primary circuits and the equally great nuisance (to say nothing of the inefficiency) of an independent alternator for each such circuit, will attach especial interest to the method by which the Portland (Or.) General Electric Company heroically parallels its single-phase alternators. It couples the shafts of the machines rigidly together so as to be mechanically in step, and operates the two machines as a single generator, sending their output down to Portland over a single circuit.

The single phasers so used are two of the three original 80 kilowatt, 4,000 volt, 16,000 alternation machines that formed the initial generator plant of the company for the utilization of the Falls of the Willamette in the incandescent lighting of Portland, eight years ago. They have now been rewound with ribbon wire and speeded up so that their combined output is 250 kilowatts, instead of 160 kilowatts as originally designed, and their heating is less than formerly. On one occasion they carried a load of 266 kilowatts during a night's run.

The instance finds an approach to a parallel in the two-phase power transmission plant recently installed by the Fort Wayne Electric Corporation at Logan, Utah, where two separate single phasers were mechanically coupled together, not in step, as in the Portland plant, but at 180 degrees, with the phases 60 degrees apart, thereby making a two-phase generator from the two machines. Three single phase machines, mechanically coupled together so that their phases shall be 120 degrees apart, form the Fort Wayne three-phase generator.

In the matter of spark coils, the San Francisco Gas & Electric Company has introduced a device for use on its Edison three-wire circuits that has called forth benedictions from every local operator of gas engines that are ignited by electric sparks. The device consists of a spark coil about five inches in length and wound to a diameter of about two and one-half inches with number 22, B. & S. cotton covered magnet wire. The coil is connected in series with a 110-volt incandescent lamp and then cut in across one side of the three-wire circuit, and all who have had to do with gas engines and have raised their voices in condemnation of the unreliability of open circuit batteries and of small dynamos for ignition purposes, have found a happy surcease from every whit of aggravation on the ignition score.

A third 400 kilowatt rotary transformer has been added to the two rotors of equal size in the sub-station of the Portland General Electric Company, and this new one, like the others, takes three phase current at 350 volts and transforms it into direct current at about 550 volts for the operation of street railway circuits. The sub-station is now never without the hum of the rotors for the truth is that whether loaded or idle, a rotor is never shut down unless it becomes necessary to trim the commutator. The reason for this is that while it is easy to put the machines in operation, it is not always that the operator is so fortunate as to hit the right interval of time that will give the proper polarity on the direct current side. Indeed, the perversity of the inanimate seems to be a particularly active genii when a rotary transformer is to be started, for while the right combination may sometimes be struck at once, it is more often that fifteen minutes are consumed before positive will come from the brushes where positive ought to be. Some one should devise a polarity teaser that would coax the three phases to deliver the proper potential on demand and without any foolishness about it.

An instance of the ease with which the voltage of transmission plants operating on the three phase system may be altered is about to be demonstrated by the San Joaquin Electric Company, which, in extending its transmission line to Hanford, 32 miles beyond Fresno, is to change its transformer connections throughout from delta to "Y," thereby giving it an initial potential at the power house of nearly 19,400 volts, instead of 11,200 volts as at present. The change will cause a shut-down for three hours or so and the capacity of the line for power purposes will be nearly doubled thereby. Incidentally, this extension again will place the Fresno transmission ahead of all others in the world in the dual capacity of the longest distance, 67 miles, and of the highest potential, 19,400 volts. The extension to Hanford will be in operation within sixty days, the contract for the work having been let to the Finance and Construction Company of San Francisco under that proviso.

If there is anything about the electric transmission plant of the Diamond Hill Gold Mining Company, of Broadwater County, Montana, entitling it to distinction, it lies in the pole line, for Nature dug the holes, furnished and set the poles, and did all but string the circuits.

Water for the operation of the plant is taken from Crow creek, whence it is carried through two and one-half miles of 3 by 4-foot flume to a point on the creek where a head of 154 feet becomes available. The water is applied to four Pelton wheels which drive a 500 k. w.

General Electric three-phase generator, delivering 2400 volts to the three-mile transmission line direct. At the mine are operated two 125 h. p. induction motors for the stamp mill, one 125 h. p. induction motor for the compressor, one 50 h. p. induction motor for the rock breakers, and two 30 h. p. induction motors for the concentrators, besides burning about 200 incandescent lamps in the mill. The stamps weigh about 1300 lbs., making one hundred drops per minute.

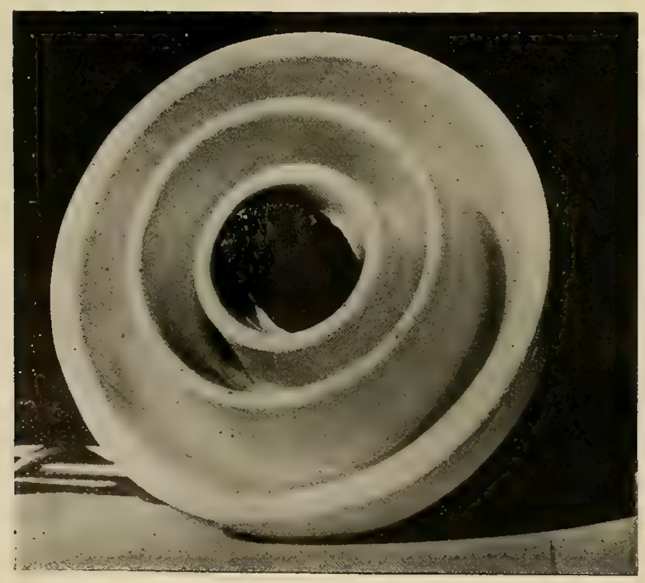
There is, therefore, nothing unusual about the transmission or its utilization, except in the fact that, as shown in the illustration, young trees are used for poles and, moreover, no great exertion was made to select high trees—that is, trees equalling the height of the ordinary pole, nor are the line circuits always run sufficiently high to prevent their being reached from the ground with but little effort.

Transmission

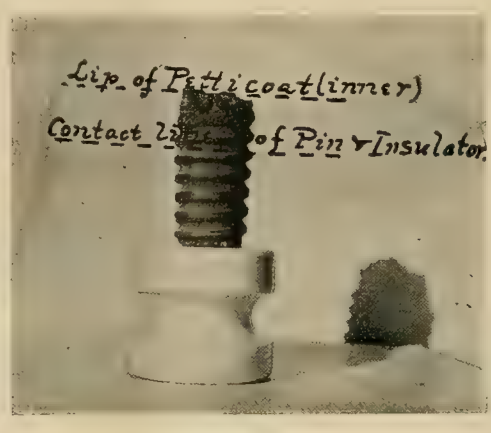
THE BURNING OF INSULATOR PINS.

By W. Stuart-Smith.

Experience with high-tension lines in California has developed the fact that with voltages of 10,000 and over, the production of insulators that will not be punctured under the static strain, or that will not allow the current to soak through the body, is not the only requisite to maintenance of line. With potentials up to, and somewhat exceeding 5,000 volts, the protection of a sufficiently resisting insulator was all that was requisite, but when potentials of 10,000 volts had been in use for a year, it was found that during the storms of the second winter the pins began to give way and during storms of several days duration, it is no uncommon thing to replace from half a dozen to a dozen pins. Destruction occurs in a variety of ways, but the most common is for the pin to burn off just abreast the lip of the inner petticoat, as shown in the illustration herewith.


A View of a Burned-Off Pin.

Discussion with the operating engineers of plants has developed the fact that this burning is generally considered to be due to heavy leakage over the surface of the insulator and wet pin, the idea being that the volume is sufficiently great to heat the pin to the charring point. If this was the case the pins would be generally found charred throughout the body, with maximum burn near the line of contact of insulator and pin and extending somewhat into the threaded portion of the insulator. As a matter of fact, the burn is generally confined to a very short length just under the lip of the inner petticoat, the lower portion of the pin and the portion screwed into the insulator being intact; also where the inner petticoat has considerable depth the pin shows no sign of burn for a distance of from one-fourth to one-half an inch below the contact line of pin and insulator. This proves conclusively that the current does not creep over the insulator surface to contact with pin and then down the latter, because in this case the line of contact would show the greatest burn, whereas it shows absolutely none at all.



The Burned Pin.

The accompanying illustrations are from photographs of the portion of such a burned-off pin left in the insulator and show clearly the clean burn-off abreast the lip of the petticoat and also the fact that the portion of the pin in the insulator and for some distance below the contact line of pin (also shown) and insulator is absolutely free from burn.

A little consideration will show that the burning is probably due to sparks passing horizontally between the pin and the lower edge of the inner petticoat. It seems probable that the electricity accumulates on the edge of the petticoat, the potential increasing until the strain becomes so great that the dielectric is pierced and a spark passes between the edge of the petticoat and the pin. Owing to the pin presenting a flat surface and the edge of the insulator being rounded, a very considerable quantity will pass at each discharge, and the burning power will be comparatively great. The manner in which these burnoffs occur is difficult to explain, except as above.

It is possible that the electricity reaches the edge of the inner petticoat by jumping from one petticoat edge to another, the path through the air being filled with spray perhaps offering less resistance than the long surfaces over the petticoats.

Pins burned in this manner are never seen on lines with a potential of 5000 volts; they are comparatively frequent on 10,000 volt lines and with potentials much in excess of this the passing of sparks and consequent burning will be so great as to render the use of plain wooden pins impossible.

It is probable that the use of some such device as the porcelain sleeve on the lower portion of the pin, introduced by Mr. Fred M. Locke, will prove effective, owing to the sparking taking place between incombustible surfaces. It is also possible that plain wooden pins could be used if a narrow metal band was placed around it just below the edge of the petticoat lip, said band being provided with two or three points extending towards the lip and taking the discharge. The quantity of electricity passing with each spark would be smaller than when the discharge passes between blunt surfaces and the burning power would be small, also the surfaces between which it passes would be incombustible.

REPRESENTATIVES OF ITS BEST PRACTICES.

WHEN the largest electrical manufacturing establishment in the world undertakes the installation of an electrical power transmission plant, it is certain that it will embody in the work the highest standard of excellence that its experience (which is the experience of a majority of plants of a similar nature) has taught it to be best. It is this idea that attaches more than usual importance to the plant which is being installed by the General Electric Company at Mechanicville, N. Y., for transmitting power to the General Electric Works at Schenectady, eighteen miles distant. The hydraulic portion of the plant has been completed and the entire installation will be in operation early in 1898. About one-third of the output of the plant will be utilized at Schenectady and the remaining power will be transmitted to Troy, and possibly to Albany.

The Mechanicville-Schenectady transmission may, therefore, be accepted as representative of the highest state of perfection reached by the General Electric Company in its apparatus for this class of work, hence the reasons why certain electrical features possessing novelty have been adopted as affording the best means for satisfying the conditions, and these reasons are fully decribed by Mr. C. P. Steinmitz in a recent contribution to the Electrical World. (Vol. XXX, No. 20.)

The frequency selected is that best suited for lighting, synchronous and induction motors, and conversion to direct current. Thus the frequencies of 125 cycles and of 25 cycles were excluded, the one as too high for rotary converters and large induction motors, the other as unfit for lighting and less suitable for smaller motors, and hence the choice lay between the standard frequencies of 40 cycles and of 60 cycles. The former was adopted as somewhat better suited for rotary converter work and for induction motors. The generators, of the type A. T. B. 40-750-120-12000, are 40 cycles unitooth three-phase revolving field type, of 40 poles and 750-kw. rating, wound to generate directly 12,000 volts, so as to avoid the necessity of step-up transformers. The revolving field type was adopted in preference to the revolving armature type, since the stationary armature winding of the former allows the construction of a generator to produce directly the transmission voltage.

The revolving field type, states Mr. Steinmitz, was preferred to the inductor type, since the latter requires very high density in the magnetic structure, and thus gives a lesser margin in voltage and in speed than the revolving field type, which latter allows the use of fairly low saturation of the magnetic circuit, thus giving a nearly straight saturation curve. Such a saturation curve, while making the machine slightly inferior in regulation to the same machine with an over-saturated magnetic circuit, is preferable in power transmission. It allows a considerable increase of voltage when needed, for instance, to cover excessive drop in voltage in lines due to heavy loads, etc., and permits the voltage to be maintained, even if the speed is low, as in the case of high water, etc. The generators are arranged to be operated in parallel at constant voltage in the generating station.

At first, 2,000 horse power will be transmitted to the General Electric Company's factories at Schenectady over a line of about eighteen miles length, consisting of three wires of No. 000 B. & S. This large size of wire has been chosen in preference to the use of several small wires in multiple in order to give the line as high a self-induction as possible. While in the early days of power transmission self-induction in transmission lines was carefully avoided in transmissions where a large part of power is taken up by synchronizing apparatus, such as rotary converters and synchronous motors, a considerable amount of self-induction in the lines is now considered desirable. In fact, if the line has too small a self-induction, as when cables are used, it is intentionally inserted in the form of reactive coils. Ths is the case in the St. Anthony Falls power transmission, which is now being installed for operating the railroads of St. Paul and Minneapolis by a number of 600 kw. rotary converters.

The receiving apparatus in Schenectady consists of two synchronous motors of 500 kilowatts and 100 kilowatts respectively for the testing department, and three rotary converters of 400 kilowatts for the operation of the factories. Air-blast transformers of the standard General Electric type are used for transforming the pressure.

At present the testing department is operated from an entirely separate power plant to secure complete independence in speed and voltage from the factory power plant. A large engine drives an M. P.-4-500-375-550 railway generator, supplying power at 550 volts to the motors in the testing department, and a smaller engine drives a number of exciters to give independent and complete control of the excitation of all machines in the testing department. An A. P. B.-12-500-400-10,000, 12-polar synchronous motor of 500-kw. rating and 400 revolutions, of revolving field type, and wound directly for 10,000 volts, will replace the engine now driving the railway generator supplying power at 550 volts to the motors in the testing department, while an A. P. B.-8-100-600-10,000, 8-polar synchronous motor of 100-kw. rating and 600 revolutions, also of revolving field type, and wound for 10,000 volts, will drive the exciter plant. By this means the testing department is made entirely independent of all changes but the frequency, that is, the speed of the generators in Mechanicville, which will be kept constant, or will at least vary only very slowly, due to the large size of the station.

Synchronous motors were chosen in preference to induction motors. It is considered very undesirable ever to use an induction motor where a synchronous motor can be used, for these reasons: Synchronous motors do not produce lagging currents as induction motors always do, so that the question of power factor does not enter into consideration, but the phase displacement in the synchronous motor and its power factor can be made anything desired by controlling its field excitation. Synchronous motors are necessarily more constant in speed and more efficient than induction motors. When of the revolving-field type they are self-starting from rest with light load, and even with fairly heavy load, and also have an overload capacity, limited only by the heating of the motor. That is, any well designed synchronous motor will easily carry two or three, or even more, times its full load without dropping out of step for a time limited only by the heating of the motor, while induction motors, when built for such overloads, necessarily give at ordinary loads a very low power factor and poor efficiency. Mr. Steinmitz states that he has never been able to drop a synchronous motor out of step by overload, but that he had succeeded in dropping a 75-kw. synchronous motor out of step by a load of 140-kw. when reducing the impressed voltage to one-half. Considering the output as proportional to the square of the impressed voltage, this would represent an overload of 7½ times full load. The excitation of these synchronous motors is constant.

Three double commutator rotaries, type T. C.-10-400-480-2x250 are in the power house, each containing two commutators and two sets of collector rings, fed from independent secondary coils of the same set of air-blast transformers. In multiple these commutators give 250 volts for the operation of the factories, while in series they give 500 volts for testing. All the rotaries will be operated in parallel, and all motors in the factories, the factory railway, the lights in the factory, and office building will be operated from the same direct-current circuit; also the lights on the Edison three-wire system. To secure the neutral wire of the lighting system, the step-down transformers of the rotaries are connected in Y with their secondaries, and a lead brought from their common connection to a lighting neutral. Since the circuit of a rotary is neutral point also for its direct-current circuit, it can be used to feed the neutral conductor of a direct-current, three-wire system operated from the commutator brushes of the rotary.

In this transmission plant it has been considered desirable to secure extreme simplicity, and leave nothing whatever to hand regulation, but make the whole system self-regulating for constant voltage, in the direct-current distribution system. For this purpose all the rotaries are supplied with shunt fields and with very powerful series fields, which are all joined together so that the rotaries in operation form one unit. The rheostats in the shunt and series fields will be set so that with constant voltage in the generating station at no load the counter e. m. f. of the rotaries as given by their shunt fields is below the impressed e. m. f. and a lagging current produced thereby. With such a lagging current the self-induction of the lines is in opposition to the voltage, and reduces the latter so as to give the desired voltage of 250 at the commutator brushes of the rotaries. With increasing load the counter e. m. f. of the rotaries rises rapidly, due to the series field, till at full load and overload it exceeds the impressed e. m. f. and the current is made leading. With a leading current, however, the e. m. f. of self-induction of the lines is brought partly in phase with their voltage, and thus increases it, so that in spite of the increased line current, and thus increased energy loss in the line, with constant generator voltage, the same voltage is produced at the commutator brushes of the rotaries at full load and overload as at no load.

This control is perfectly automatic, and would be sufficient, if the synchronous motors did not take power also over the same line in amounts varying independently of the load on the rotaries. To take care of this small series transformers will be inserted in the lines leading to the synchronous motors and feed a small synchronous motor generator, which controls the shunt fields of the rotaries, so that, independent of the load on the lines and the distribution of the load between the synchronous motors and the rotary converters, the voltage will automatically be maintained constant at the commutator brushes of the rotaries by the combined action of their shunt and series fields, leaving nothing for hand regulation except the readjustment of the rheostats in case of a change of the number of rotaries in operation.

Pneumatics

AN ELECTRO-PNEUMATIC TRANSMISSION.

A unique transmission plant has recently been installed at Ely, White Pine County, Nevada, for the Chainman Mining Company, by the Westinghouse Construction Company, under the engineership of Mr. W. V. Lockwood, of San Francisco. Water for the operation of the plant is taken from a spring whence it flows through 1 1-2 miles of ditching and 1800 feet of 24-inch slip joint pipe to the power house, where it is applied to a 5-foot tangential wheel under a head of 500 feet. Direct coupled to the water wheel is a 120 kilowatt Westinghouse two-phase generator supplying current at from 0 to 2400 volts to four number 4 B. & S. bare copper wires leading to the mines, not quite three miles distant. At the mines the circuit is led through a switchboard possessing no distinctive features, to a 150 h. p. Westinghouse two-phase induction motor which drives a duplex air compressor, compressing air into three receivers, each measuring 12 feet in length by 5 feet in diameter.

It is from these receivers that air is taken for the operation of all the machinery about the mine. In detail, this consists of one 60 h. p. hoist, driven by two 10 by 12 engines; one 10-stamp mill, driven by a 10 by 30 Corliss engine; a cyanide plant, driven by an 8 by 24 Corliss engine; and two 6 by 12 simple engines which drive the rock breakers, the concentrators and the electric light plant. In addition, a single sinking pump lifts 20 inches of water up the shaft to an elevation of 230 feet. The compressed air is all reheated before being used and for this purpose there are three reheaters consuming one-half a cord of wood daily.

It should be understood that for all practical purposes the generator is rigidly connected to the air compressor. as there is no device installed whereby the motor may be switched off or on by any variation in the pressure of air in the receiver. Instead, however, three signal circuits are carried from the receivers to the power house and by means of these, the burning of a red incandescent lamp indicates that the pressure of air in the receiver is above normal; the burning of a green lamp shows that the pressure is too low, while the burning of a white lamp signifies that the normal pressure prevails. The station attendant varies the speed of the generator according to the signals received, thereby controlling the compressor as required.

Prof. Hutton states that two dangers beset engineering schools, the first of which is the danger of conferring the degree on mathematicians who are not and never can be engineers in the true sense of that term, and the second danger is the shutting out from the profession some who, by reason of their talents in some special field of engineering, would rise to distinction.

Metallurgy

PLATINUM IN GOLD PLACER DEPOSITS.

The constantly increasing demand for platinum in the arts and manufactures of the world and the present limited sources of supply, have in recent years greatly enhanced the price of the metal. Because of the peculiar and valuable qualities of platinum it is believed that the consumption of the metal would be greatly increased if the supply was sufficient to materially lower the cost.

This article is published, therefore, for the purpose of calling the attention of prospectors and miners to the increasing demand for the metal, even at present prices, and to the wide distribution of the ore, with the hope that by their aid new and rich deposits of the same may be located.

Contrary to popular impression, platinum and associated metals are widely distributed, although they have thus far been found in paying quantities in but few localities. This condition is perhaps largely due to the higher intrinsic value of gold and to the limited acquaintance of prospectors and miners with the means of identifying platinum ore and of its economic separation. Up to the present time the platinum of commerce has been obtained entirely from alluvial deposits, although it has been reported in limited quantities in its natural position. About eighty per cent of the present supply is derived from the alluvial deposits of the Ural Mountains, but there are few, if any, of the gold-bearing gravel beds of the world that have failed to yield platinum, and it is more than likely that large quantities of platinum ore have been thrown away with the black sand washings from gold placer deposits. The distribution of the ore may in fact be regarded as practically coexistent with gold placer deposits, as is evidenced by the following list of localities, excepting Russia, that have yielded the ore in varying quantities. In California in nearly if not in all of the gold-bearing gravel and sands; in Oregon, Georgia, North Carolina, Alaska on the Yukon River, Canada, British Columbia, Mexico, Columbia and Brazil, South America and Australia.

The genesis of native platinum is not well understood. In two cases it has been reported as found in quartz veins, but these reports have never been verified, and the theory of deposition from solution based upon them is rendered extremely doubtful, by the known insolubility of the metal. The undoubted occurrences of platinum in its natural position are in Russia, Brazil, New South Wales, Canada and Colombia.

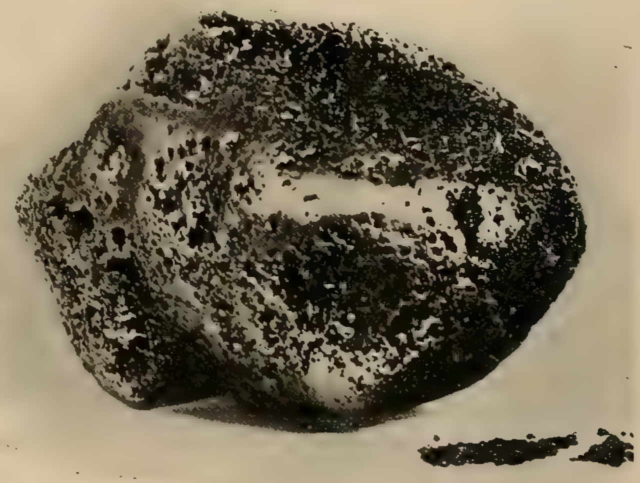
Platinum ore is usually found in the form of rounded or flattened grains or "sand," occasionally in irregular lumps of the size of peas; large nuggets are very rare—the largest as yet found weighing twenty-one pounds.

The ore has a metallic lustre and is distinguished by its steel gray color, shining light gray streak when rubbed on a hard white surface, high specific gravity (16 to 19), infusibility in the hottest blast furnaces and insolubility in any single acid. It is not affected by borax or salt of phosphorus before the blowpipe, except in the finely divided state, when reactions for iron and copper may be obtained. It is soluble only in hot nitro-hydro-chloric acid.

Platinum ore is a complex body consisting of the metal in combination with varying proportions of the other members of the platinum group, such as iridium, rhodium, palladium, ruthenium and osmium, together with from four to twenty per cent of iron. In alluvial deposits the ore is generally associated with iridosmine (a native alloy of iridium and osmium possessing a degree of hardness superior to that of hard-tempered steel), magnetic iron sand, chromite, garnet, epidote and often with zircon, serpentine, ilmenite, peridot, quartz, diamond and chrysolite. Russia is the only country, excepting possibly New South Wales, that at the present time mines platinum ore for itself alone.

In the former country the platinum-bearing sand is found at depths of between six and forty feet, the "pay streak," averaging less than a foot in depth, resting directly on serpentine bed-rock. In New South Wales the "pay streak" is from sixty to one hundred and fifty feet wide and underlies a loam bed sixty to seventy feet deep, the ore occurring in the crevices of the bed-rock and in the gravel resting thereon.

The method generally adopted for extracting the ore is to pass the sand and gravel with water through puddling machines or revolving conical screens; the platinum and fine sand pass through into sluice boxes beneath, while the coarser materials are discharged at one side. The contents of the sluice boxes are washed in the usual manner, and when gold is present in paying quantities it is removed by amalgamation with mercury, the platinum remaining behind. Experience shows that it is seldom profitable to work mines yielding less than three grams of platinum ore to the ton of gravel. The average yield of the richest Russian mines is about six grams per ton. The refining of crude platinum is a difficult operation to perform and requires apparatus and experience not generally available, except at the hands of specialists.



The platinum nugget illustrated full size on this page is, undoubtedly, the largest ever found on this continent. It measures approximately three by two and three-quarter inches and weighs nearly two pounds. It was shipped to Baker & Co., of Newark, N. J., from the western coast of South America in February, 1897, but the facts appertaining to its discovery and early history are obscured by reason of its repeated transference from owner to purchaser. The illustration also shows in the lower right-hand corner crude platinum sand of the average form and dimension.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity, Gas and Power.

OFFICIAL ORGAN OF THE PACIFIC COAST ELECTRIC TRANSMISSION ASSOCIATION.

Subscription Payable in Advance. Terms—Domestic, One Dollar per Year; Foreign, Two Dollars per Year.
Rates for Advertising on Application.

The trade supplied by the San Francisco News Company.

EDITED AND PUBLISHED BY GEO. P. LOW.

Business Office, 516 COMMERCIAL ST.
Telephone, Steiner 623.

Address all communications to
Editorial Rooms, 427 TENTH AVE

SAN FRANCISCO, CAL.

Entered as Second-class Matter at the San Francisco Postoffice

Volume V. DECEMBER, 1897. Number 3

EDITORIAL.

WORKING OUR WAY ABROAD.

The press has recently announced that the London office of an American electrical concern has closed an important electric railway contract with the companies operating the tramway systems of Dublin, Ireland, and Barcelona and Madrid, Spain. The Dublin contract comprises six 500 horse power engines; six 500 kilowatt multipolar railway generators, 3000 horse power of water tube boilers, and 150 complete street railway equipments, with trucks, all being of American manufacture. The Spanish contract was also of American build exclusively, and included 2000 kilowatts generator capacity, together with full station equipment.

Speaking in generalities, the perfection of the details of efficiency and adaptability seems to be the ambition of European engineers, and so great an extent has this aim prevailed that each installation appears to possess every possible refinement, worked out with the utmost nicety to fit the conditions which exist. All this is exemplary and it is worthy of emulation to the fullest extent, but American manufacturers are in a business world pervaded with an industrial atmosphere peculiar to itself, as a result of which its products, too, possess distinctive features. May not the efforts of European engineers be properly likened to those of the electrical manufacturer who attains the highest possible transformer efficiency under a given load, and are not the efforts of the American engineer comparable to the endeavors of the electrical manufacturer who attains the highest possible "all day" efficiency in the transformer he builds?

The machinery patterned after the ideas of the European and American schools of engineering is now in the marts of the world and whichever receives the greatest patronage will win the coveted prize of a name for superiority. This much seems evident, however, that American apparatus is not only holding its own at home, but it is actually working its way into European markets.

TWO SISTER SCIENCES.

It is futile to hope that engineering will reach the highest plane of excellence through the channel of a single one of its branches, and with a problem embodying diversified conditions it is oft-times unreasonable to maintain otherwise than that the products of different fields of engineering will afford the materials from which may be derived a perfect practice or the nearest approach thereto. Steam will always have its exclusive sphere of usefulness, and so will compressed air, electricity, and all other lines of engineering, but for the pneumatic engineer to close his eyes to the frequent superiority of electricity, or for the electrical engineer to condemn compressed air as fit to fulfill only limited services, are unworthy expressions. In mining, for instance, pneumatics and electrics each have, on occasions, peculiar fitnesses unapproached by any other agency, and in the harmonious working of the two, each to subserve the purpose for which it is especially adapted, will be found the nearest approach to ideal engineering.

The first instance in which compressed air and electricity have been systematically harnessed, is found in the transmission plant recently installed at Ely, Nevada, as described elsewhere in this issue. The transmission proper is effected through the agency of electricity, the energy from which drives a compressor that, in turn, operates all the machinery about the premises, including hoists, stamp mill, rock breakers, concentrators and the cyanide plant. The electrical features of the plant are therefore restricted to a 120 kilowatt generator, the transmission line, and a 150 horse power induction motor, all the remaining equipment being operated by compressed air.

Unless local conditions afford a conclusive reason for the operation by compressed air of those portions of the plant as constitute an even load, it is questionable if the sacrifice in efficiency due to the conversion from electricity to compressed air will not overbalance the additional cost of motors to operate the even load referred to, albeit the steam plant formerly existing may be rendered idle. Electric power in any form affords the ideal mode of running stamp mills, rock breakers, concentrators and all other even loads in mining machinery, but with hoists, as with rock drills, there is little question but that compressed air furnishes a means of operation at present superior to that to be derived from the application of current taken from transmission circuits. In fact, an inherent characteristic of polyphase motors is that they operate to best advantage when under constant or slightly varying load. Conversely, they are inherently but ill-adapted to the relentless fluctuations imposed by mine hoists of heavy duty. Such work is well taken care of by direct current apparatus, but the additional cost of its installation and the absence of economy in throwing out steam hoists when they can be operated perfectly and at a high efficiency by air, compressed by polyphase motors, turns the balance to the favor of pneumatics. The near future may, however, reverse this situation.

Nevertheless, the Ely installation is evidence of a long step in an interesting direction and the success it will probably achieve will add to the rapidly growing conviction that pneumatics and electrical engineering are sister sciences, helpful alike to each other.

THE TRUTH, BUT NOT THE WHOLE TRUTH.

An article in the Cosmopolitan for December on, "A Greater National Newspaper," conveys the impression that there does not exist in America today a single daily newspaper that is above sectarianism, or party affiliation, or business association, sufficiently to be accepted as the embodiment of all that is desirable in both its news pages and editorial utterances. Without doubt class or trade papers are not to be included in the same category, for in their ranks are to be found noteworthy exceptions to the odium that attaches to the biased expressions of the publication that "has an axe to grind." Truly has it been said that you can fool some of the people all of the time, and all of the people some of the time, but not all of the people all of the time.

As with newspapers, so with advocates in every line of business; but one is quite unprepared for the concealing of an iota of truth by an able engineer and writer of no little just renown who, in comparing the revolving field with the inductor type generator, gives preference to the former because the inductor type "requires very high density in its magnetic structure, and thus gives a lesser margin in voltage and speed than the revolving field type, which latter allows the use of a fairly low saturation of the magnetic circuit, thus giving a nearly straight saturation curve. Such a saturation curve, while making the machine slightly inferior in regulation to the same machine with an over-saturated magnetic circuit, is preferable in power transmission. It allows a considerable increase of voltage when needed, for instance, to cover excessive drop in voltage in lines due to heavy loads, etc., and permits the voltage to be maintained, even if the speed is low, as in the case of water, etc."

It would be absurd to intimate that the writer referred to is not perfectly familiar with the fact that the Stanley generator, for instance, which is typical of inductor machines, does not require such density in its magnetic structure as to necessitate running at a serious closeness to the saturation point. Indeed, this inductor is not only capable of increasing the e. m. f. 20 per cent above normal by excitation, but in addition it is provided with an armature coil connecting switch, termed a regulator head, which may be constructed to produce an e. m. f. of any desired range either above or below normal, without any extraneous devices. The increase or decrease in voltage that may be obtained from the Stanley inductor is, therefore, far beyond that range attainable from single variations in degree of saturation. Of course magnetic regulation presents the advantage of being both instantaneous and automatic in action, and while embodying this mode, inductors for the reason given are capable of far exceeding the limit of regulation by magnetic means. The amount of this excess regulation which may be required is easily determined in each specific installation, after which the regulator head may be set as desired, precisely as though the degree of over-compounding necessary was manually effected. The admitted inferiority of regulation in a machine with a straight saturation curve, to one having an over-saturated magnetic circuit, renders further consideration of the proposition unnecessary, until the whole truth is told, when the honors regarding the regulation of revolving field and inductor type generators may be more understandingly considered.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

PURE POLITICS, THEN PUBLIC OWNERSHIP.

From the evidences at hand (which, it must be admitted, may be of a doubtful nature, inasmuch as they are from the columns of the possibly subsidized press), it appears that Socialists will not find a crumb of comfort in the years of experience which the city of Philadelphia has had in owning and operating a gas plant. The end of this municipal control was reached last month, when a Court of Common Pleas decided that no injunction may stand restraining the city from leasing the gas works for a long period to a private corporation. The weight of the opposition to municipal control becomes tangible in the assertions made that such concerns as Cramps ship yard and the Baldwin Locomotive Works, through their managements, together with scores and scores of other most solid business institutions of the city, supported the lease.

In 1895, Mayor Stewart, in his annual message to the City council, gave an exhaustive and indeed, roseate report on the gas plant. It appeared from his report that the total expenditure of the gas bureau from 1891 to 1894 inclusive for material, labor, supplies, etc., were $10,858,910.58, and for extensions and permanent improvements, $1,050,248.81, making a total of $11,909,159.39. During the four years previous there was returned into the City Treasury as receipts for the gas plant, $14,790,404.25, or nearly $3,000,000 in excess of the entire expenditure. The report commented on this as being a very good showing in face of the fact of a reduction from $1.50 to $1.00 per thousand feet, while the quality of gas remained the same. In addition, nearly two and one-half million feet of gas was furnished for street lighting, for which the gas department received no credit and which, had the city been compelled to purchase at even one-half the price paid by private consumers, would have cost, $1,649,651.00—which was also looked upon as a clear profit.

It is indeed a great drop from the very favorable showing of Mayor Stewart's report ,to the occurrences of the past month, wherein the principal tax-payers of the city have, from all accounts, risen in revolt to the further squandering of their money in the maintenance of a gas plant that has proven a sinking fund wherein millions are annually absorbed by unbusinesslike methods and the machinations of political cliques. No private corporation would adopt as a permanent policy the buying of a commodity from a second concern at a far higher figure than it could possibly sell it to the public, yet this is what the municipal plant of Philadelphia has been doing, and which, along with many other things, has wrought its ruin.

Still, after all, it does not appear that the failure of the city gas plant in Philadelphia is so much an arraignment of Socialistic theories as it is an evidence that the time is not yet ripe for municipal ownership in the larger cities, and as it is a bitterest condemnation of the incompetence and unworthiness of American politics.

ELECTRICITY AND THE PRESS.

The great conflagration which visited the English metropolis on November 26th and which destroyed property variously estimated from $5,000,000 to $40,000,000, has been attributed to the explosion of a small gas meter in Well street, and now the old controversy as to the relative incendiary proclivities of gas and electricity bids fair to be reopened by the English electrical press. The London Electrician observes: "Man's old enemy Gas, had another beginning in London last week." Then after reviewing the cause and consequences of the fire, it quotes a surveyor for fire insurance risks in London as stating that "Electricity is no longer the bogie it was, and I wish there had been more of it and less of gas in Well street."

It seems rather late in the game, however, to invite discusion of the long-since-settled question as to whether in gas or electricity is to be found the greater fire-bug, but nevertheless, so industrious is the daily press concerning electrical affairs that had a fire as disastrous as the London conflagration have been attributed to electricity as its origin, the public would not have had to await the slow channels of the trade or technical press for full information concerning it. The eyes and admirations of the family of man are lovingly centered on the infant science and its every developing trait of character is watched parentally with favor or fear according to its tendency. Though grown to stature and even in many respects ahead of its day, the quondam "infant" is still an infant indeed in the eyes of the human family, and if the child (?) knows nothing more, it has certainly learned already that fire cannot be played with without administering burns, and it hurts to be burned. Electricity has learned its lesson well and avoids every feature that may lead to disaster in this direction, but still the people of the world look on as parents are wont to do, overlooking the maturity of their offspring and fearful lest it does not know enough to "come in out of the wet."

May there not be found in this idea a reason why the daily press—that self-annointed custodian of the public weal—never ceases to prate on matters electric?

AN ELECTRO-HYDRAULIC ANALOGUE.

The "Engineering Magazine" (Nov., '97), in referring to the description of the electric transmission plant of the Power Development Company, of Bakersfield, Cal., appearing in the Journal of Electricity for August last, observes that an interesting feature of the plant is that practically all of the power is used in pumping water for irrigation purposes. After outlining the mode by which this is done, the "Engineering Magazine" points out that the Bakersfield plant offers an example of transformation of water not dissimilar to electrical transformation, in that a moderate volume at high pressure is transformed into a large volume at low pressure, and the intervention of the turbines, generators, and electrical transmission forms an intermediate detail of this unique installation.

AN OXIDATION RESISTING ARC CARBON.

A German electrical contemporary publishes an account of a Russian patent for the manufacture of carbons for arc lamps. These carbons are composed of the purest possible carbon and carbide of silicon pulverised very finely, mixed and united with a binding material, such as tar. A mixture of 90 per cent of carbon and 10 per cent of carbide of silicon is found to be a very good proportion, but it may be varied. They can also be made with a core of carbine of silicon, or with threads of the latter combined with some such conductive body as carbon. Since carbide of silicon is only formed at about the temperature of the voltaic arc it does not contain volatile ingredients and it has the highest power of resisting oxidation of all known bodies. It develops light of a greater intensity, and in consequence it appears to be well adapted for the purpose, but as carbide of silicon does not itself conduct electricity, it can only be used in the voltaic arc in conjunction with carbon.

Electro-Therapeuty

ACCUMULATORS IN DENTISTRY.

ELECTRICITY, in its wonderful progress, has not hesitated to encroach upon every avenue of industry, from the displacement of the mule, in the coal mine, to the radiating of a soft, mellow and perfect light in the stores of merchants or in the homes of the well-to-do. Steam, that emblem of civilization, which has long been looked upon as the ne plus ultra of human progress, no longer holds an undisputed field, and indeed, it is not usually necessary to consider its installation if water power is available within a reasonable distance from the point of consumption. From such heavy work as drawing a railway train, one can turn to the same subtle force toiling on with equal faithfulness, running a fan, silently and steadily, at the bedside of the sick, or coming to the rescue of the factory girl, who, day by day, bends over her sewing machine and blesses the little electric motor that lightens her task and increases her earnings. This magnificent science reaches into every avenue of business, and dentistry is not the last to awake to the new era and discover the comforts, conveniences and luxuries that electricity affords.

The dental profession has long realized in the good old treadle engine a staunch and faithful friend, yet it has not kept pace with the times. The first substitute suggested was doubtless the water motor, but this did not meet all requirements and its use is now uncommon. Then a simple but efficient electric motor—the Griscom motor—was put upon the market to meet the demand for a small power, but as the only available means for supplying current for its operation, was by the use of troublesome acid batteries, its field of usefulness was limited. Indeed, the experience of years has taught the lesson that acid or primary batteries will seldom prove satisfactory or economical where a continuous current of electricity is required for any considerable length of time. The installation of electric power circuits then followed and all small power consumers believed that with the advent of these circuits would come the day when the problem in question would be satisfactorily solved. The motors worked nicely; the speed was under almost perfect control and all was serene. About this time, however, electric mallets came into use, and it occurred to more than one that it would be a good idea to run the mallet from the power circuit. The experiment was tried, but, at the time of their introduction the current on the power circuits was generally at high potential and the early experimenters in some instances realized that no sooner had the mallet reached the teeth of the patient than a shock of varying severity was administered the patient. These shocks were caused by the leakage of the then dangerous current to the ground through the patient's body, and it is fortunate for the interests of the electric motor industry that no fatality occurred. Now, however, these high pressure currents are no longer utilized in the principal cities of the country, if at all, and nearly everywhere low tension direct current circuits are available from which even mallets may be operated without fear of injury.

Electrical accumulators, as storage batteries are sometimes called, have now been placed on a high plane of perfection and their importance is becoming more and more marked. As its name implies, the storage battery is a reservoir in which electricity or its chemical equivalent may be accumulated or stored. The process of this accumulation, though not as simple as the dozen analogies that might be named, is yet such as should be well understood by one with a slight knowledge of chemistry. The battery, or cell, in its simplest form consists of two grids of cast lead separated by strips of gutta percha or vulcanite forks. In practice, it is found convenient to multiply the number of plates of lead according to the storage capacity the battery is to have, and ordinarily an accumulator consists of a given number of plates, five, for instance, three of which—the negative plates—are joined to a common lead bar forming the negative pole of the battery, and the remaining two—the positive plates—are burned together to a second lead bar which forms the positive pole of the battery. By removing the insulating separators, the pile as it is called, may be resolved into its component parts, the positive and negative sets of plates. In one of the earlier and more easily explained form of storage batteries, these plates are each formed of a lead grid, and into the squares of the positive plates was compressed a paste consisting of minium or red lead ($Pb_3 O_4$) and sulphuric acid ($H_2 SO_4$); while the squares in the negative plates were filled with a paste of litharge ($Ph O$) and sulphuric acid. The pile was then connected together by means of insulating forks and after being submitted to a "forming" process of over a week's duration, the battery was ready for the market. After placing the pile in the cell containing dilute sulphuric acid and after forcing a current of electricity through it, the battery became charged, or in common words, the current was stored.

This process of accumulating electricity may be briefly described as follows: It is well understood that in all chemical batteries electricity is manifested as a phenomena attending the reduction of some metal, generally zinc, to one of its salts. When the storage battery is first set up and immersed in sulphuric acid of the proper specific gravity, no current can be drawn from it and it is not until after the battery has been charged that it is capable of delivering electricity. This charging process consists in passing a current through the battery and effecting thereby the reduction of minium to lead sulphate ($Pb_3 SO_4$); the reduction of lead sulphate to spongy lead, and the formation of sulphuric acid.

The chemical action is as follows: During the passage of the current in charging, the sulphuric acid (H_2SO_4) of the solution unites with the minium or red lead (Pb_2O_3) of the positive plates and the oxygen set free from the same pole, forming lead per oxide (PbO_2), plumbic sulphate ($PbSO_4$) and water (H_2O), according to the equation,

$$PbSO_4 + 2H = H_2SO_4Pb.$$

The PbO_2 which is formed slowly accumulates in the bottom of the cell in the substance known as "per oxide mud," while the $PbSO_4$ combines with the hydrogen set free from the negative plate as follows:

$$Pb_3O_4 + H_2SO_4 + 2O = PbO_2 + 2PbSO_4 + 2H_2O.$$

thus forming spongy lead and adding H_2SO_4 to the liquid. It is plain that this addition of sulphuric acid to the liquid during charging must result in constant increase of the amount of sulphuric acid in the liquid or electrolyte.

Though it may appear at a glance that serious injury might occur to the cell by reason of this increase of acid, such is not the case, for as the specific gravity of the liquid increases the charge in the battery increases and by the use of the hydrometer a certain indication of the amount of current in the battery is had. In discharging the battery the process is reversed, hence if the hydrometer shows the specific gravity of the electrolyte to be but 1.160, then the current in the electrical reservoir is near the bottom, so to speak.

If the hydrometer reads 1.200 there is no need of further charging, as running more current into the battery would be like pumping water into a tank already filled to the brim.

Having obtained an idea of the construction and principles of the storage battery and in order to explain satisfactorily its capacities and capabilites, it will be necessary to have some slight knowledge of electro-techniques. It must be learned then that what is commonly called a current of electricity is a composite substance or thing, we know not exactly what. It has two factors, the volt and the ampere, neither of which can exist without the other, and it follows that if a current exists, it must exist upon something. That something is the metallic conductor through which it travels and if a current of electricity flows through a conductor, it encounters a resistance, the amount of which regulates the flow of current. In electricity, the unit of pressure or potential, or that factor which enables the electric current to overcome resistance and to do work, is the volt. The resistance offered by any conductor as opposing the flow of electric current, is measurable and the unit of such resistance is the ohm. It is the volt that pushes the working property of the current through the resistance of the conductor, and the unit of the working property referred to is defined as the ampere. No current can exist without a conductor for it to travel upon. That factor of a current known as the ampere can not alone traverse a wire, for the same reason that water can not be made to go through a pipe unless some forcing pressure is applied to it. Conversely it is impossible to apply a volt alone to a conductor, as it is obviously impossible to apply pressure unless there is something to which it may be applied. The mission of the volt is to force the ampere through whatever ohms of resistance there may be in the conductor.

The layman should now be in a position to again take up the storage battery. The pressure that is derived from each cell is about two volts, quite irrespective of whether the largest or smallest cell is used. If four cells are connected one after the other in tandem or in series, the combined pressure or potential of the battery of four cells will be four times two volts or eight volts, which is an electrical pressure that may not necessarily be exceeded in electro-dentistry. The current from these four cells will fuse quite a large piece of wire, yet it is quite harmless as may be demonstrated by placing the battery terminals upon the tongue.

While the voltage of every cell is the same, regardless of its size, the amount of current each contains is directly proportional to the surface of its plates. Current enough can be stored in one of the smallest cells made to return two volts and two amperes for four and a half hours, or as it is technically called, the cell has a capacity of nine ampere hours. That is, it will give a current of one ampere for nine hours, or two amperes for four and a half hours, etc. The capacity of a battery best suited for dentists' uses is about 150 ampere hours; hence, if a dental mallet requires one ampere to operate, this battery will contain enough current on one charge to run the mallet 150 hours either continuously or intermittently.

In this connection may be mentioned a feature of the storage battery that alone makes it pre-eminently the superior of all acid or primary cells. In the use of the latter excellent results are obtained for several minutes after a new solution has been placed in the cells. The battery soon polarizes, however, or, in plainer words, the chemical tension or stress of its elements are brought to a state of partial equilibrium and as a result of this polarization the current rapidly grows weaker, until in a comparatively short time, it is of no use. In happy contrast to this, is the action of the storage battery; it does not polarize or run down and a dental engine when run from a storage battery will work as strongly the last hour as it did the first hour. In continuing the comparison between primary and storage batteries it may be stated that in the latter are no zincs to wash and amalgamate, there are no carbons to clean and it contains no acids that need to be changed and renewed. It is a perfect institution that gives only perfect results.

The question may now arise, how is the flow of current from the battery regulated? and in answer it must be brought to mind that in mechanics with a given power, the more friction there is to be overcome, the less will be the effective work that can be done. So it is in electricity, for the amount of current in amperes that passes is in inverse proportion to the resistance of the conductor through which it travels. If a wire having a resistance of one ohm be connected across the poles of a storage battery, about two amperes of current will flow through the wire. If the wire has a resistance of two ohms, one ampere of current will flow, etc. This is illustrated in the use of the speed regulator, by means of which more or less German silver resistance wire is thrown into circuit with the battery and electric motor. When resistance is added to the circuit by depressing the lever, less current becomes available for driving the motor, and the speed is reduced, and vice versa.

It is thus by the insertion of resistance into, or its withdrawal out of, the circuit, that varying effects are obtained, such as changing the speed of a motor, or altering the brilliancy of an incandescent light. After this manner may be operated laryngoscope, cautery points, motors, drills, and other electrical devices, and there are perhaps none in the profession who will not appreciate the application of electricity to heating air in air bulbs for drying cavities before filling. Heretofore it has been necessary to resort to the spirit lamp to heat the air in the barrel of the bulb, but in the electric air blast all that is necessary to obtain hot air, is to press the thumb switch and a blast of air, heated to the desired temperature, is available. This heat, too, may be regulated by the rheostat.

Perhaps the most universal application of electricity to dentistry is in the use of electric motors for driving dental engines, buffing or polishing outfits, etc. With four cells of storage battery of dental size, any speed, or any power sufficient for dental purposes can be obtained under the most perfect regulation. At the foot of the operator is a rheostat, or speed regulator and depressing it to a greater or less extent, the motor is started and driven at any required speed. In event the drill point becomes entangled in rubber sheeting, or if it is deemed necessary to reverse the direction of rotation, this is quickly accomplished by means of a simple switch moved by the foot. A majority of dentists using electric power are obliged to stop the motor, take off the belt and give it a half twist whenever they desire to reverse the drill. That this is not necessary is apparent. The motor is so constructed that it draws current from the battery in almost exact proportion to the work being done, hence practically no energy is wasted in maintaining a maximum power to meet a possible demand. The motor automatically and without the aid of any external mechanism instantly responds to whatever work is imposed upon it within its range and when its load or work is lessened, the consumption of current from the battery is decreased accordingly. The speed of the motor is practically constant and it does not slow down appreciably when performing ordinary work. When desired, however, the speed may be varied by means of the pedal regulator as described. The power given is more than ample to meet all of the requirements of a dental engine, and in proof of this statement, it is easily shown that a dental motor is capable of driving a surgeon's circular saw through a piece of bone an eighth of an inch thick. Perhaps the hardest work that can be imposed upon a motor in a dental laboratory is the running of a polishing lathe, yet this too is handled with ease.

In cases where abundant current for charging purposes is available it is a reasonable proposition to heat water for rinsing the mouth by electricity. To do this it is only necessary to take the proper piece of resistance apparatus from its hook and immerse it in glass of water. The act of raising it from the hook can be made to close the circuit and permits the current to run through the resistance wire about it which becomes hot and heats the water. It takes from one to three minutes to heat a glass of water to the proper temperature; hence, in practice, it is best for the operator to place the heating apparatus in the water soon after the patient takes the chair. In installations in which the storage batteries are kept charged by gravity batteries, the heating of water by electricity is not recommended because of the great amount of current consumed in the process.

There are several ways in which dental storage batteries may be charged. When the ordinary gravity, or blue stone battery is used, a small stream of electricity is constantly running into the storage battery, tending to keep it always charged. The gravity battery requires the least attention of any primary cell and the expense of maintaining it is but slight. Accumulators may be charged from any continuous current, electric light or power circuit, and many prefer to send their cells to a central station for recharging. None of these methods are without some trouble or expense and where arc light wires are used, the danger of personal injury from shocks is serious, owing to the high tension of the current that the wires carry. The charging of dental batteries from city direct current mains is easily done, but the means which must be adopted for cutting down the voltage makes the cost of charging high, and to run a charging dynamo from an electric motor supplied with current from city mains, involves considerable investment in apparatus. In order to avoid the trouble and inconveniences of acid batteries for charging, or the expense of obtaining current from a central station, or the danger attending the use of arc or motor circuits, some operate a miniature charging station which can be placed in every office where there is a fairly good water pressure available. It consists of a small water wheel and a still smaller dynamo that requires but about one-twelfth of a horse power to drive it. When the hydrometer indicates that the current is about drawn from the battery, it is only necessary to turn on the water, start the dynamo and the little machine will charge the battery as thoroughly as the current obtained from an electric lighting station. For the ordinary work of one dental chair it will hardly be necessary to run the dynamo oftener than one day in each week or fortnight, if the water pressure is good. If it is neither possible nor convenient to use the water wheel there may be a gas engine or other power in the building, from which the trifling amount of power required to run the dynamo may be obtained. In the country a small wind mill will furnish ample power to run the dynamo and the fact that the power may be unsteady or intermittent will make no difference in the operation of apparatus from the battery.

Transportation

FLOODING AN ELECTRIC CONDUIT ROAD.

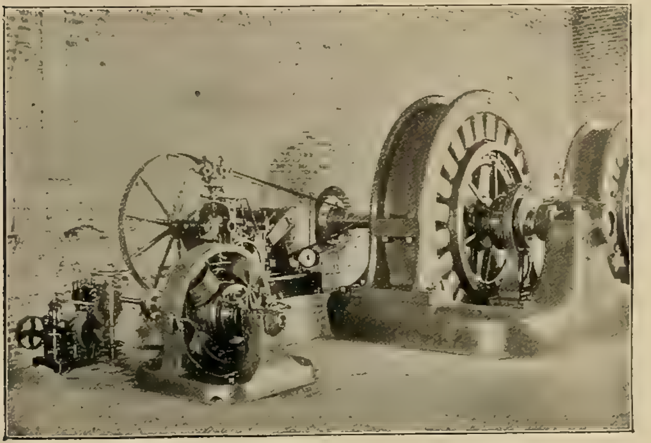
The behavior during flood times of an electric street railway, operated on the General Electric open conduit system such as the Metropolitan Traction Co., of New York, is so extensively laying down, is of interest, as ignorance of it has formed one of the principal motives for decrying it. While no flooding of the conduit has ever occurred on the Lenox Ave. line, it has been averred that, if it were flooded, traffic would necessarily stop, owing to short circuit, until the water had been run off. That this is not the case is shown by an interesting experience on the line of the Metropolitan Traction Co. in Washington, D. C.

October 9th, 1897, as the result of a heavy rain storm, a stretch of track, some 150 feet long on the F street line, became completely flooded, the water filling and overflowing the conduit as it was unable to run off by the usual sewer connection, which was cut off. According to the statement of Mr. Weaver, President of the road, although the conduit was completely filled with water for nearly two hours, the station was not short circuited, nor were the water rheostats called into requisition. The normal load of the feeder for the section is 300 amperes, the loss during the time the conduit was flooded was 600 amperes, and the cars were also operated on the sections on both sides of that which was under water. The water was practically pure and this partially accounts for the small additional load.

The Washington electrical conduit system, although its conduit has been several times flooded, has never yet been tied up, except once when the water almost covered the floors of the cars and flooded the motors. At other times the line has been operated by means of a reducing rheostat. The present instance is the only one in which the flooded section has been operated directly from the generators without reducing medium. It was estimated that the pressure of the current on the cars in the centre of the flooded portion was about 250 volts.

THREE PHASE TRACTION.

The first trial trips on the electric railway up the Gorner Grat, near Zermatt, Switzerland, were carried out last month in the presence of the inspectors of the Swiss Railway Department. The section already completed has a length of 1,600 metres and a gradient of 12 per cent. The tests gave complete satisfaction, both the ascent and descent of this gradient being effected without the slightest difficulty, the motors holding the locomotive perfectly to its proper speed. Starting on the maximum gradient with a fully-loaded train was also effected with great facility. The Gorner Grat road is a rack railway, the total length being about six miles and the maximum gradient 20 per cent. The power is derived from the Findelbach, which drives four turbines of 250 h. p. each, coupled directly to three-phasé alternators of 5,000 volts and 40 alternations per minute. Transformers are placed in the power house itself for feeding the line as it passes the building, and two other transformer stations are provided. The tension of the trolley line is 550 volts. Each locomotive is equipped with two three-phase motors of 90 h. p. each, driving the main pinions by spur gear.



Owing to the property of three-phase motors, by which they will act as generators and take up the full power which they are designed to give out as motors when driven at 2 or 3 per cent. above the speed of synchronism, the locomotives will, in descending, give power back to the line. In case only descending trains should be on the line, the surplus power will be taken up in a water resistance in the power house. The contractors for the whole of the electrical equipment are Messrs. Brown, Boveri and Co., who, in the well-known Lugano tramway, were the first to apply the three-phase system directly to traction. They have also supplied the electrical parts for the Jungfrau railway, where their system is to be adopted, and are now engaged on the equipment of the line from Stansstaad to Engelberg, which is to be running next spring. —London Electrical Engineer.

The Baltimore and Ohio South Western Railway has been experimenting with electric motors on turntables. Turning locomotives at divisional points and terminals is a service of much annoyance and no little expense to railroad companies, as it generally takes four men to turn a locomotive and while they are doing so their regular work is abandoned.

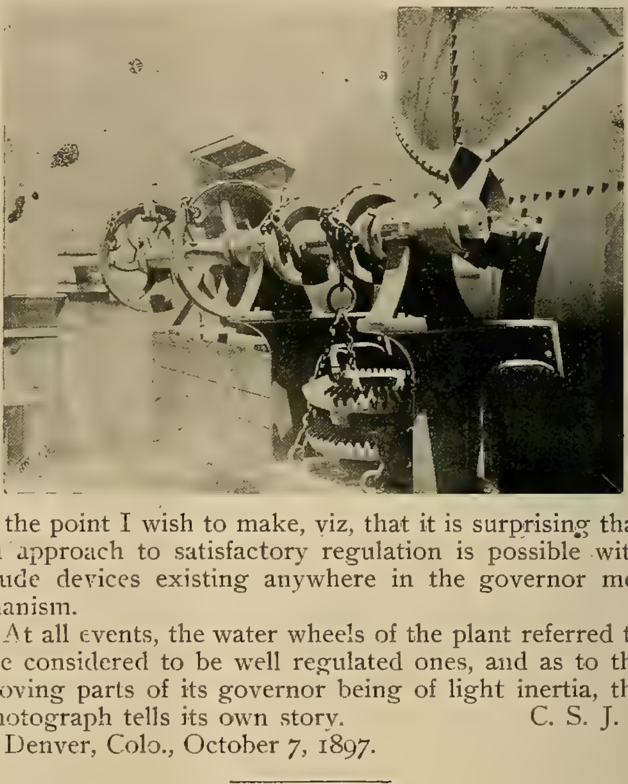
Experiments were made with an electric motor on the 60-foot turntable at Chillicothe with such success that the Park street turntable in Cincinnati was similarly equipped. The result has been rather astonishing in the matter of expense. The current was purchased from the power plant and it cost on an average of less than one-half a cent for each time the table was turned. When this same table was operated by hand it cost 12 cents for each engine. The yearly saving is about $709.

Hydraulics

INERTIA IN GOVERNOR MECHANISMS.

To The Editor: While reading the leading article on "Water Wheel Regulation" in your September number, I was impressed with the emphasis laid on one of the points made, namely, that sensitiveness in the government of water wheels is largely due to a minimum inertia of the moving parts of the governor. The conclusion seemed to naturally follow that if light, quickly-moved parts are material to success in one portion of the mechanism, they should be as light and as easy moving and as nicely balanced in all other parts of the governor as is consistent with mechanical strength, to secure close regulation.

This condition is not always believed in, or at least it is not always carried out, nor is its existence always necessary, and this statement will, I think, be admitted as correct after an examination of some of the devices that are used for regulating water wheels in the West. The accompanying photographs of a governor shaft in an electric power plant were taken a year or so ago and illustrate the point I wish to make, viz, that it is surprising that an approach to satisfactory regulation is possible with crude devices existing anywhere in the governor mechanism.



At all events, the water wheels of the plant referred to are considered to be well regulated ones, and as to the moving parts of its governor being of light inertia, the photograph tells its own story. C. S. J.

Denver, Colo., October 7, 1897.

Personal

Mr. Clifton Morton, Jr., local manager of the New York office of the National Tube Works Company, was recently on his annual trip through California.

Mr. T. A. W. Shock, formerly of the Sacramento Electric, Gas and Railway Company, has accepted the general superintendency of the Portland General Electric Company, to which city he has gone.

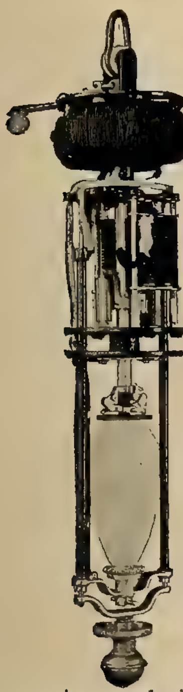
Mr Stephen D. Field, whose many important inventions in the electrical engineering field have added further to the worldwide fame of his illustrious family, and whose earlier electrical experiences were in California and the West, was a recent and most welcome visitor to San Francisco about a fortnight since. His trip West was for pleasure and recreation.

Mr. W. A. Burkholder, who is one of the most experienced electrical transmission engineers in the country, is now in Alaska, but will probably locate in San Francisco. Mr. Burkholder has resigned the position of Gen. Superintendent of the Portland General Electric Company, which he has held for many years, but still remains in the directory of that vast concern, as well as in the directory of the Union Power and Willamette Locks and Transportation Companies.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

ENCLOSED ALTERNATING CURRENT ARC LAMP.



Perhaps the most objectionable feature of such alternating current enclosed arc lamps as have heretofore been placed on the market has been their too low economy and noisy, uncertain action. In the new alternating current arc lamp, manufactured by the General Electric Company, these characteristics are overcome. It operates on constant potential alternating circuits with higher economy and greatly diminished noise. The principles of the enclosed arc lamp and the economical advantages of its use over open arc lamps are familiar to our readers, but as between open and enclosed alternating arc lamps, it is not so generally known that a greater difference in economy in favor of the enclosed lamp is shown than in the same comparison between open and enclosed direct current arc lamps. In the G. B. alternating current enclosed arc lamp, one pair of carbons will last between 60 and 70 hours and induce a saving of about 80 per cent in the cost of lamp carbons; a larger arc is maintained; the light is emitted without obstruction; and its protection from currents of air and any sudden action of the mechanism allows the light to become and remain steady.

The mechanism is simple, the number of moving parts being reduced to a minimum, and its action is quick and positive. A special adjusting spring keeps the current constant whatever the position of the core. The mechanism is supported on a frame with a double base which gives a dead air space and provides protection for the mechanism from the heat of the arc.

This lamp operates on circuits of 100 to 120 volts and 60 or 125 volts frequency. About 70 volts are required at the terminals of the arc, and the normal current being 5.5 to 6 amperes. An inductive resistance contained within the ornamental top of the lamp, and connected in series with the arc, gives the necessary reduction in the voltage, and, preventing sudden changes in current, checks any unsteadiness of the light. The half-inch carbons used are 9½ in. long in the upper holder and six in., in the lower one cored, the other solid, and they must, of course, be of high grade. They are proportioned to allow the piece left in the upper holder after one run, to be used in the lower holder for the next. The inner globe is supported by a self-locking device. To lower the globe, the lower ball is unscrewed, the globe is raised slightly and released by turning the release screws on the side of the cylinder. To replace it, the globe is simply raised until it locks, when it is tightened by screwing up the lower ball.

The General Electric alternating current enclosed arc lamp is 28¼ in. in length and 31⅛ pounds in weight. It is artistic in its proportions and is judiciously ornamented. For interior illumnaton, i, e., for halls, large stores, restaurants, theatres, public buildings, the casing of the lamp is finished in ground brass or black enamel; for outside use a weatherproof casing is furnished.

ENLARGING THE BUFFALO-NIAGARA PLANT.

While the attention of the electrical transmission fraternity of the West is being absorbed in the development of their own enterprises, it is interesting to note the progress that is being made in the extension of the more prominent transmission plants of the East. Most noteworthy of these is, of course, the Niagara-Buffalo transmission, which is now undergoing a considerable increase, the demand for power from Buffalo having within the past few months grown beyond the capacity of the line first put up. The three wires strung on the poles, will have shortly three companions, and the white insulators on each pole, will be increased to six.

A new order for cable as well as for transformers has been placed with the General Electric Company. The cable is of special manufacture, is insulated to stand the ultimate pressure of the line, which will be 22,000 volts, and is tested under a considerably higher presssure before leaving the works. Twenty-four thousand feet of this cable will be used at first for that part of the transmission line within the city of Buffalo. The order for increasing transformers covers seven of similar size and design to the three now installed in the transformer house of the Niagara Falls Power Company. These ten transformers are the largest ever built. Each has a capacity of 1,250 h. p., making a total step-up transformer capacity of 10,000 h. p. They are of the air-blast type, and will stand in rows of four upon the air-tight chamber, whence the air is forced through the ventilating spaces in the transformers. It will be remembered that the two-phase current at 2,200 volts passes from the 5,000 h. p. generators in the power house to the transformers. In these it is not only increased in pressure but changed in phase, the current issuing from the transformers as three-phase current at 11,000 volts. This pressure will be adopted until it becomes necessary to increase it, when it will be doubled and be delivered to the transmission lines at 22,000 volts. On its arrival in Buffalo it will be delivered to the step-down transformers of the Cataract Power and Conduit Company, which controls its distribution there. The electricity will be transformed down to different pressures for distribution over a city network to different points for a variety of purposes, being used directly in induction motors, a number of which will probably be installed in grain elevators, etc.

Several step-down transformers will also be placed in the station of the Buffalo General Electric Company, and from these three-phase current, converted into direct current in rotary converters will be utilized for lighting purposes and for small power units.

The Buffalo Railway Co. is also increasing its step-down transformer and rotary converter capacity in its Niagara Street Power House. In addition to the two 500 h. p. converters already in operation, the General Electric Company has built two others of similar capacity and construction. These will bring the total converter capacity in the station up to 2,000 h,

p. To supply these necessitates the installation of three additional step-down transformers in the transformer house between the station and the canal. These will be of about the same capacity as the three already there—each of 275 kw., reducing three-phase current from about 10,500 volts to 375 volts for delivery to the alternating current side of the rotary converters in order that they may issue direct current at 550 volts, at which pressure it is delivered to the bus bars of the station switchboard.

While the foregoing equipments are exclusively those of the General Electric Company, the Westinghouse Electric and Manufacturing Company has closed important contracts in and about Niagara Falls as follows: The most noteworthy contract of the Westinghouse Company is that with the Cataract Construction Company for an enormous addition to the great station at Niagara. It consists of five 5,000 h. p. generators of the same pattern as the three installed at present. In addition to these five machines which are now under way,—in fact their shipment has already commenced,—the factory is also building exciters, representing a capacity of 675 h. p. The switchboard, with necessary appliances, controlling the five 5,000 h. p. generators, is also being made now and all of these machines will be applied to the Niagara Power House as soon as required.

The Niagara Falls Hydraulic Power and Manufacturing Co. some time ago, contracted with the Westinghouse Co. for six 750 h. p. direct current generators, 300 volts, 250 r. p. m. These generators will be direct connected to Leffel turbines and they will be used for generating current that will be supplied to the Aluminum Factory of the Pittsburg Reduction Co. at Niagara.

The company has also constructed two 300 h. p. two-phase induction motors, contracted for by the Buffalo-Niagara Falls Electric Light and Power Company, to be used for driving alternating current generators, direct current generators, arc machines, etc.

The Niagara Electro-Chemical Co. has contracted for a large increase in its transformer station, located above the power house of the Niagara Falls Power Company, and consisting of three 235 h. p. two-phase rotary transformers and one 175 kw. rotary transformer supplying current for the reduction of metallic sodium from caustic soda. In addition to these transformers, the Westinghouse Company is also making for the same company 800 h. p. in air-cooled oil converters, consisting of six 133 h. p. converters, 3,000 alternations, which will supply current for the rotaries.

The Acetylene Light and Power Co. has contracted for two 1000 h. p. oil converters, water-cooled, of 3,000 alternations, primary 2,200 volts, secondary 100 volts. These converters will supply current for arc furnaces for the manufacture of calcium carbide.

The Mathieson Alkali Company contracted with the Westinghouse Company some time ago for a number of rotary transformers, induction motors and oil converters, which were recently installed and consist of 11, 165 h. p. rotary transformers, several small induction motors, twenty-two 82½ h. p. oil converters, four 33½ h. p. oil converters, and two 13½ h. p. oil converters.

These facts are the best evidence of the growing activity manifesting itself in the use of electrical apparatus at Niagara Falls, all of which has been occasioned by the erection of the large power station of the Cataract Construction Co., the generators for which were installed by the Westinghouse Electric and Manufacturing Company.

ELECTRICITY IN MINE HAULAGE.

"The Operation of Electric Mining Plants" forms the subject of an attractive pamphlet recently issued from the press of the General Electric Company. It is devoted more especially to the installation, use and economy of operation of electric mining locomotives and lists, 75 electric locomotives aggregating 2,860 h. p. In addition to describing some noteworthy installations, the pamphlet contains valuable and apparently impartial data that is of exceptional interest to mining managers who are striving to attain the highest possible efficiency in mine haulage.

The publication of a booklet on the same lines with that just considered, but having for its theme the operation of mining hoists driven from polyphase motors, is next in order, and its advent is earnestly awaited.

TABLE OF CONTENTS.

Illustrated articles are indicated by an asterisk (*)

Authors

W. Stuart-Smith 56

Editorial

The Truth, but not the whole Truth 61
Two Sister Sciences 60
Working Our Way Abroad 60

Electro-Economics

*Some Station Wrinkles 49
I—How Mount Lowe is Climbed 50
Part II—The Saving of Oil 51
Part III—Water Rheostats 52
Part IV—Compressed Air 53
Part V—Miscellaneous 55

Transmission

*The Burning of High Potential Pins, by W. Stuart Smith 56
Representative of its Best Practices 57

Pneumatics

An Electro-Pneumatic Transmission 58

Metallurgy

*Pedinum in Gold Placer Deposits 59

Passing Comment

Pure Politics, then Public Ownership 61
Electricity and the Press 62
An Electro-Hydraulic Analogue 62
An Oxidation Resisting Current 62

Electro-Therapeuty

Accumulators in Dentistry 63

Transportation

Flooding an Electric Conduit Road 65
Three-Phase Traction 65

Hydraulics

*Inertia in Governor Mechanisms 66

Industrial

*Enclosed Alternating Current Arc Lamp 67

Personal

Burkholder, W. A 66
Field, Stephen D 66
Shock, T. A. W 66

The Journal of Electricity

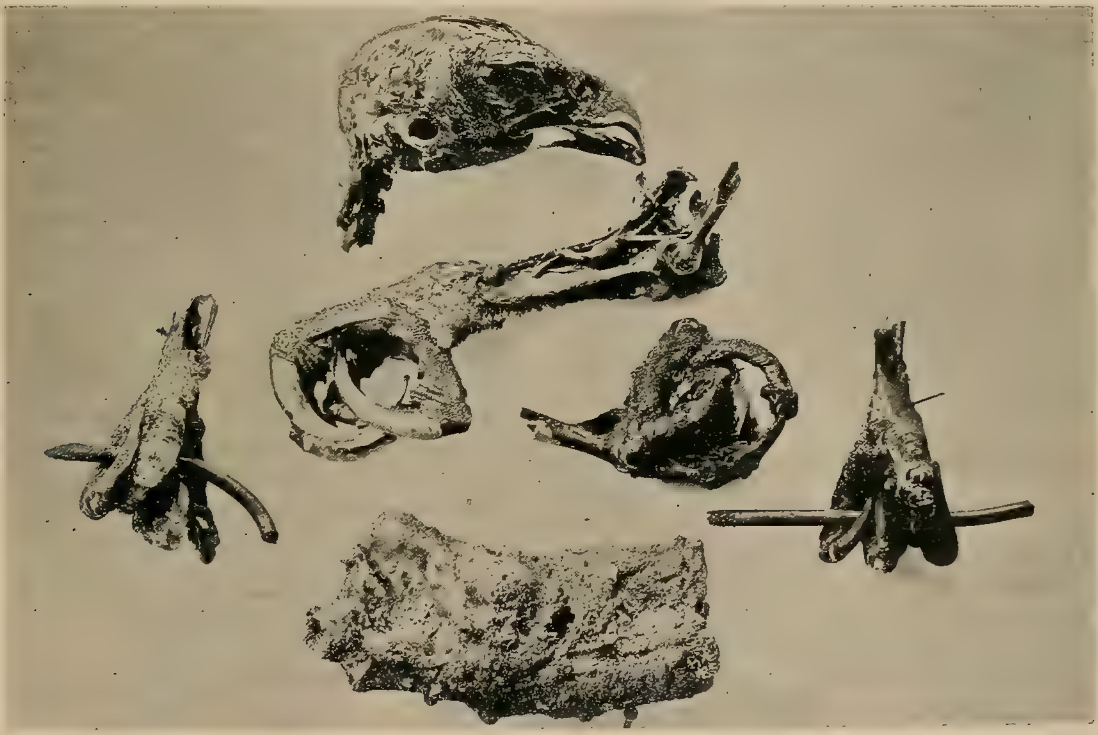
Vol. V. JANUARY, 1898. No. 4

Some Transmission Practices.

GRUESOME indeed are the sanguinary relics here reproduced with the best skill of the engraver's art! They are all that remain of two eagles, which had the temerity to alight on a high potential transmission line of the San Joaquin Electric Company, of Fresno, Cal., and the vindictiveness of the 10,000-volt circuit at the interference is here attested.

To particularize, the transmission plant was running with its usual serenity one day last fall, when, like the traditional thunder-clap from a clear sky, one of the transmission circuits developed a dead short circuit, with the almost instantaneous open-circuiting and grounding of the two legs of the circuit which are on the upper cross arm. This, of course, interrupted the service in Fresno, and the ground thus thrown on was so severe that it became impossible to burn it out. After a few minutes delay, the service was resumed over the second transmission line, which had remained uninjured.

Linemen were sent out at once to ascertain the cause of the trouble and repair the broken circuit, and after having gone over nearly thirty miles of line, they reached a mountain top about five miles from the power house where the break was discovered. As to the cause of it, there were found the scant relics of two grey eagles, consisting merely of one skull and four feet and parts of legs. Two of the talons were clutched tightly to the line wires in literal realization of the grip of death while the remaining two feet and parts of legs were free from the marks of roasting, or rather from the burning to a crisp, that characterized the feet that clutched the wires. Not a vestige of the bodies or feathers of either bird, nor of the head of one of them, could be found—in fact, the only remains were those given in the illustration. Another interesting specimen was found, however, which shows the teriffic heat of the electric arc. The soil along the pole line at the place indicated consists of pure granitic sand, which, wherever the wire touched the ground, had become melted into glass and even a piece of quartz had been fused and run in together with the glass. This is well shown in the specimen presented in the illustration.



THERE WAS A "HOT TIME" ON THE OLD LINE.

The circumstance of the accident suggests a theory for it, as evidently the two eagles alighted on different legs of the three phase circuit within close proximity to each other; that they actually came into contact and in so doing formed a short circuit which not only incinerated the eagles, but threw the wires into short circuit and burned them off.

The question has been raised as to whether the accident was due to two male eagles battling for supremacy, or whether the short circuit was formed by a "love-lorn billing and cooing pair"—a point upon which yellow journalism may decide.

Part 1

SYNCHRONIZING TWO PHASERS.

Where ever the question of synchronizing devices receives consideration, a point is invariably raised as to whether it is preferable to throw in the synchronizing switch at the moment of maximum brilliancy of the incandescent lamps, or at the moment of their extinguishment. Beyond all peradventure of doubt, the first method is the preferable one, for the reason that a slight variation in voltage is far more readily discernable when the lamp is at or near full candle power, than when it is at the opposite extremity, or at the point where there is no voltage applied to it. In other words, if a 100-volt lamp is used on the synchronizer, it will require, say, 30 volts before it will be brought up to a perceptible degree of luminosity, hence there is a variation of 30 per-cent in the voltage applied before the eye can discern any variation of voltage whatever. On the other hand, if the lamp is taking 100 volts, the eye will detect a variation of two volts or less in the potential applied, hence the superiority of synchronizing by any method which synchronizes when the lamps are at full candle power, over any method which synchronizes when the lamps are out.

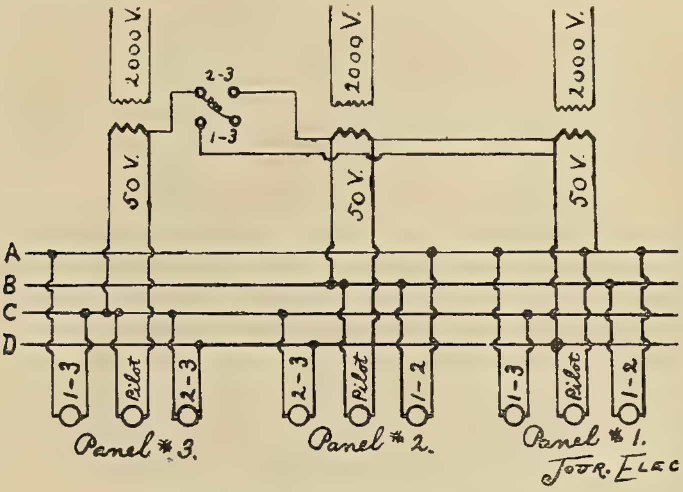
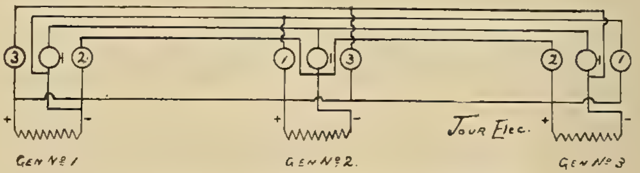


FIGURE 1—SYNCHRONIZING TWO PHASERS.

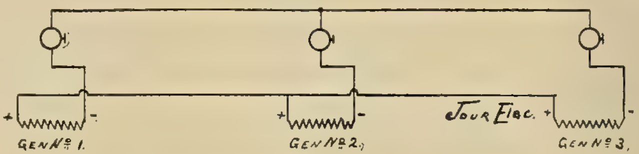
A method of paralleling two phase machines, and as used at the electric power plant of the Blue Lakes Water Company, was described in the Journal for October last and, that its mode of operation may be recalled, it is here reproduced. In two phase systems, the leading phase only is used in synchronizing, and in the mode in use at Blue Lakes City, the leading phase of each generator supplies current to the 2000-volt synchronizing transformer on its respective panel, as shown in the scheme of circuit connections outlined in figure 1. These transformers reduce the generator potential to 50 volts and each has a capacity of 500 watts.

The only portion of the synchronizing equipment that appears on the front of the switchboard is a small U-plug switch, by means of which the circuit combinations of the secondaries of the synchronizing transformers are changed, and three pilot lamps on each of the three generator panels. The center lamp in each case is an ordinary 50-volt pilot lamp for indicating that the dynamo is in operation, and the remaining two outside lamps of each panel are 100-volt lamps for indicating synchronism between its particular generator and either of the other two generators. Referring to panel No. 1 of the accompanying diagram, for instance, the pilot lamp appearing in the center is directly connected across the secondaries of the switchboard transformer. On the lamp at the left is indicated synchronism between generator No. 1 and generator No. 3, while the lamp at the right of the panel indicates synchronism between generator No. 1 and generator No. 2, as appears on the diagram, and so on through the remaining panels.



PLAN A—SYNCHRONIZING TWO PHASERS.

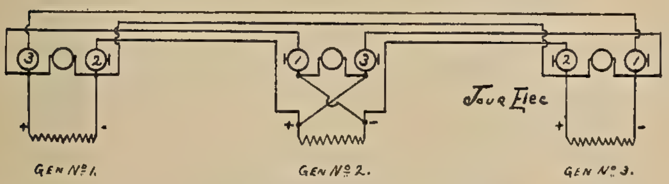
In synchronizing generator No. 1 with generator No. 2, the U-plug is withdrawn, which cuts out the plug switch from the circuit. The pilot lamps of panels 1 and 2 are assumed to be burning, but the generators are, of course, running on independent bus-bars. The two synchronizing lamps appearing as shown on panels 1 and 2 for indicating synchronism between their respective generators, are turned on by the key sockets. This done, the circuit connections of the synchronizing equipment may be readily traced.



PLAN B—SYNCHRONIZING TWO PHASERS.

It is to be understood that the secondaries of transformers 1 and 2 are coupled in series and feed into the small bus-bars lettered A and B. If now generators 1 and 2 are in synchronism the transformer secondaries will be in phase and their potential being cumulative, will give a pressure of 100 volts across bus-bars A and B. If, however, the generators are out of step, the bus-bar potential will be reduced in direct proportion to the amount of drag in either generator. At intervals the phases of the two transformers are in direct opposition and the bus-bars consequently have a zero potential. In the next instant the relative positions of the phases may have so changed that the transformers will be in but half opposition, which will give a potential of about 50 volts to the bus-bars, while a fraction of a second later the phases may be in step, giving full potential to the 100-volt lamps, which show synchronism and at the instant the synchronizing lamps reach full candle power, the main switch must be thrown in coupling the generators in parallel.

The U-plug switch is used only in synchronizing generators 1 and 3 and generators 2 and 3, and the use of the switch merely connects the secondaries of transformers 1 and 3 and transformers 2 and 3 respectively so that the circuits shall be in the same condition as already described for synchronizing generators 1 and 2. There is but one precaution necessary to take, and that is that all synchronizing lamps shall be turned off at the key socket except those used for synchronizing, otherwise it is possible to throw a potential of 150 volts onto the synchronizing lamps of generators 1 and 3, if the U-plug is in the wrong position.



PLAN C—SYNCHRONIZING TWO PHASERS.

Four other schemes for synchronizing two-phasers are shown in the accompanying diagrams designated as plans A, B, C and D, and in which it is well to note that the horizontal lines in the diagrams are not bus-bars, but merely show the secondary connections from the various synchronizing transformers. In plans A and B, which afford by all means the simplest ways of making connections for any number of generators, the synchronizing lamps are out when the machines are in parallel. Plan C accomplishes the same thing as plan A with the exception that the synchronizing light is at full candle power when the machines are in parallel. Plan D is an arrangement which shows in addition the method of paralleling two sets of generator bus-bars, shown by dotted lines by the use of two extra transformers, in which case the lamps X and Y must be for 100 volts. Obviously synchronizing transformers, may be substituted for the bus-bar connections shown.

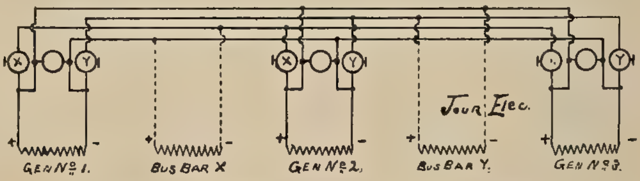
In these diagrams the primary circuit of the transformers are omitted for simplicity, the secondaries being shown as generator terminals direct. The synchronizing lamps are characterized by circles with keys, while the circles containing figures represent single pole switches connecting to the generator circuit indicated.

Part ii

AN HISTORIC TRANSMISSION.

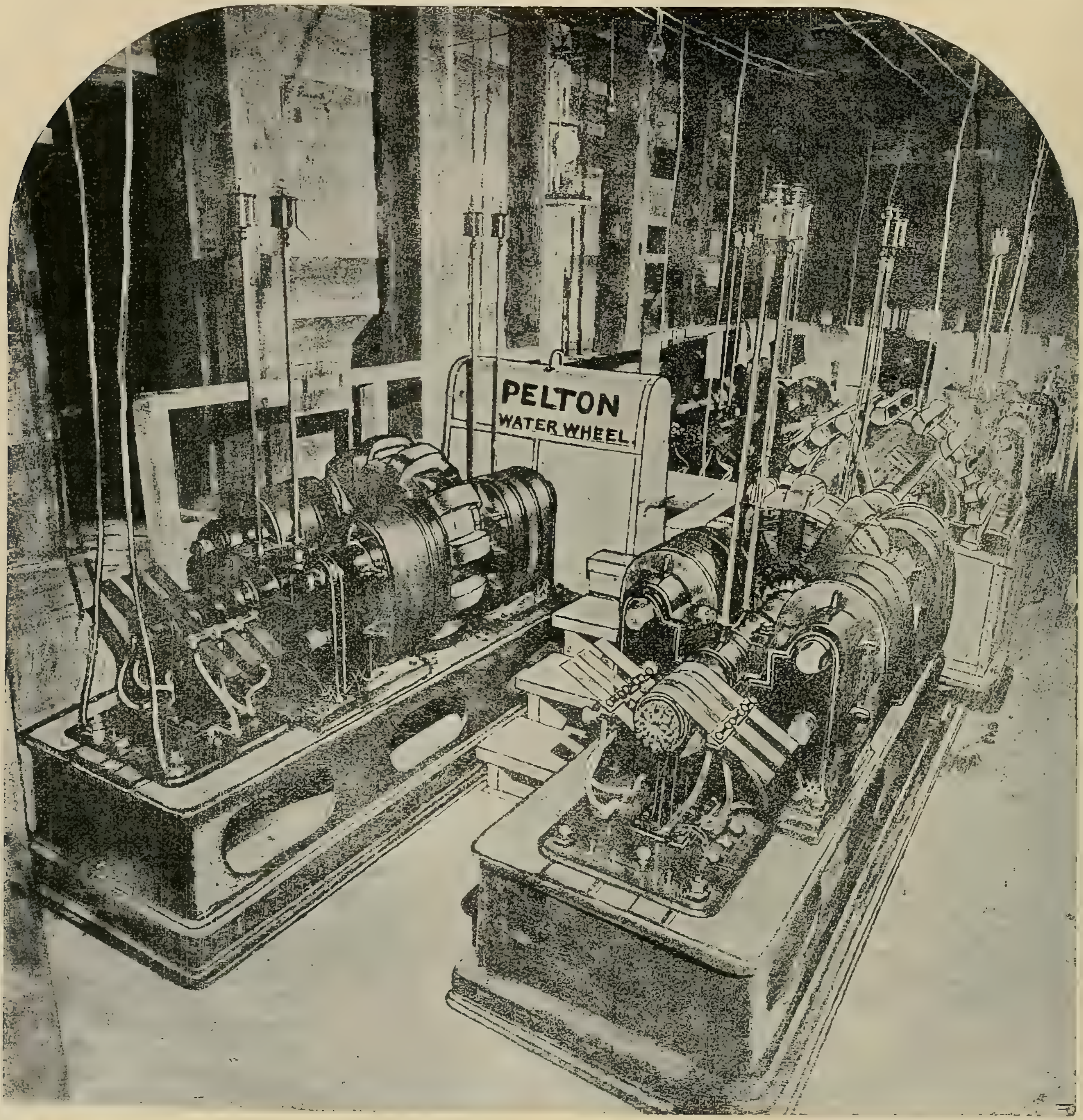
Of great interest is the power transmission plant placed in the Chollar shaft on the Comstock in 1891 for operating the 60-stamps of the Nevada mill. Before that time the Nevada mill consisted of 40 stamps with the usual complement of pans, settlers, etc., which had been run with a 10-foot Pelton water wheel by water supplied from the Gold Hill Water Company's main under a head of 460 feet. When the mill was enlarged to 60 stamps with additional amalgamating machinery, requiring in all some 400 horse-power, the question of securing this power with a degree of economy that would admit of working the low grade ores, was the problem. Fuel being scarce, steam power was out of the question. Water was also expensive, the only source of supply being brought from the Sierras through a pipe line 30 miles in length.

The Sutro Tunnel afforded an outlet some 1,700 feet below the surface, and the utilization of this immense pressure was decided upon in connection with electric transmission, as being the most feasible. A station was made by excavating a chamber at the Sutro Tunnel level, 1,680 feet below the surface, 25 feet in width, by 50 feet in length. In this were located six Pelton wheels 40 inches in diameter, connected to the shafts of the same number of Brush dynamos, both running at a speed of 900 revolutions per minute. These Brush generators were of the constant current type, delivering 30 amperes at a variable electro-motive force. They were compound wound having a high resistance series shunt, with a small series winding merely sufficient to build up enough field to maintain 30 amperes in the series field winding on short circuiting the brushes. The generators were each of a rated capacity of 100 horse-power, while the water wheels were rated at 125 horse power. The generator circuits were taken to the switchboard where they were so arranged that the output of any particular machine could be thrown on to either of the outgoing circuits. The line was carried out through the shaft on glass insulators, and consisted of No. 4 wire covered with special Clark insulation throughout. After leaving the shaft the six circuits were carried to the motor room adjoining the mill, making the total transmission of about one mile. As intimated the six generators were each provided with separate circuits from which were operated six 60-horse-power constant current electric motors of the familiar type of the Brush arc machine. These motors were arranged in a single



PLAN D—SYNCHRONIZING TWO PHASERS.

row paralleling the main driving shaft to which they delivered power by belting. To this driving shaft was also belted the 10-foot Pelton wheel heretofore referred to as being operated from the Gold Hill water system, and together the six motors and water wheel thus operated the stamp mill. The electric plant was sold by the late Geo. H. Roe and was installed under the direction of Mr. F. E. Smith, now Chief Electrician of the San Francisco Gas and Electric Company.



POWER ROOM OF THE HISTORIC TRANSMISSION IN THE CHOLLAR SHAFT.

Aside from the interest which is attached to the uniqueness of this electric installation, the hydraulic plant is striking because of the novel use of waste water and the terrific head under which the plant operates. The water used was taken from the tail race of the 10 foot surface wheel referred to, whence it was piped down the shaft to the intersection with the Sutro Tunnel at the 1680 foot level, where, as stated, the generator room was chiseled out of the solid rock. Here the wheels were located and the water of the tail race was carried out to Sutro tunnel. Each of the six water wheels weighs 220 lbs. and delivers 125 horse-power from a jet of water five-eighths of an inch in diameter. The wheels are of phosphor bronze, 40 inches in diameter, and when running without load, have a speed of 1800 revolutions, with a peripheral velocity of 18,864 feet, or more than three and one-half miles per minute. The water is delivered from a nozzle at a speed of 19,260 feet per minute, forming a stream that for all practical purposes is as invulnerable as a bar of steel. Though the plant is now idle, it remained in constant daily use for more than six years and would be in operation today were it not that the mill is closed down.

Part iii

CHANGING INSULATORS ON LIVE LINES.

A method of changing insulators on a 10,000-volt transmission circuit while the current is on the line, is described in a recent number of the "Electrical Review" (N. Y.), and the evident practicability of the scheme will doubtless bring it into favor in the many electrical transmission plants of the Pacific Slope. The electrical transmission plants of the Pacific Slope. The practice which is universal in the West, is to shut down the plant to change an insulator, or, if duplicate transmission lines be provided as is the case at Portland, Sacramento and Fresno, to throw the whole load on to one circuit, while the men are at work on the second one.

The experience has been that if let alone, porcelain insulators give very little trouble on lines carrying potentials between 5,000 and 6,000 volts. In the line of the Nevada County Electric Power Company, which is operated within the limits of voltage given, no attempt is ever made to change insulators when the current is on for the reason that unless the insulator is completely shattered and the wire is on the cross arm, it is not necessary to replace a broken insulator, as "partly broken insulators cause no trouble whatever, even in severe storms," writes Mr. L. M. Hancock, superintendent of the company.

It was with a view of learning the experiences of the different transmission plants in regard to changing insulators on live lines, that letters were addressed to the principal transmission installations of the Coast, and the results of the correspondence which followed are here presented. The prevailing practice is probably well set forth in the letter of Mr. Arthur W. Burt, of the San Antonio plant, who is confident that his company uses "the best method and the only safe one. It is perfectly simple: Never change an insulator or have anything to do with a high tension wire while the current is on. In adhering to this rule, our service has as yet suffered no injury and we shall leave it to others to find some safe method of 'monkeying' with high tension wires."

Mr. E. W. Sutcliffe, electrical superintendent of the Central California Electric Company, states that thus far it has not been found necessary to change insulators on a live high potential line. It has been the custom, in event it became necessary to change an insulator, to shut down between the hours of 12 m. and 1 p. m. and to use a portable telephone on the lines so that notification may be given the power house as soon as the insulator is replaced. This occasions a shut-down of but three or four minutes. "We have lost but thirty-four insulators in eleven months' service," continues Mr. Sutcliffe's letter, "and anticipate but little trouble this winter. Of course, with a change in conditions, we would have to devise some method of handling defective insulators without a shut-down, but we have not found it necessary to do so to date."

Mr. C. W. Hutton, chief electrician of the Sacramento Electric, Gas and Railway Company, related the experience of the Folsom-Sacramento plant as follows:

"As you are aware, we have a double pole line, and our method of changing insulators is simply to shut the current off from the line needing repairs, the only precaution taken being to short circuit and ground the line on which the men are to work. This is done by a piece of wire bent into the shape of the two sides of an equilateral triangle. Small hooks are bent into the two ends of this V-shaped wire in order to engage two of the lines, and the elbow of the triangle is brought into contact with the third line. The triangle is tied by a tie wire to an insulator, and into the insulator a stick about two feet long is screwed, to be used as a handle. A long cable connects the triangle to a steel pin that is driven into the ground before the man goes up the pole to ground the line on which the insulator is to be changed.

"This shorting and grounding was found to be necessary for the reason that on several occasions, linemen have received quite severe shocks while working on a "dead" line while the other was in use. These shocks necessarily give a man a feeling of uneasiness, but no trouble has been experienced since this device has been used, as it is evidently impossible, while using it, for current to be put on to the line by mistake or otherwise. It is certain that no injury can happen to any one who may be working on the wires when so protected."

The maximum potential on the transmission lines of the Portland General Electric Company is about 6,000 volts, and, owing to the multiplicity of circuits between the power houses and the substation, no effort has been made or is likely to be made, toward changing insulators on live lines. Neither has an arrangement yet been made for changing insulators on the 15,000-volt lines of the Pioneer Electric Power Company, of Utah, nor has it ever been the practice of the Big Cottonwood Power Company to remove defective insulators and replace them with good ones on live high pressure lines. Regarding the Big Cottonwood plant, Mr. R. M. Jones, Engineer and Manager of the Company, writes: "Our custom from the first has been to shut down the station absolutely between 12 m. and 1 o'clock in the day, every Sunday, and it has also been our custom to travel over the entire length of the line as often as twice a month in the night during stormy weather, if storms occur during the month. The object of this is to ascertain the location of any leaky insulators, which is readily determined by a spark something like that of a firefly, and from that, larger, during damp weather. This can only be seen in the night. We have no difficulty by burning out or by capacity loss in allowing such leaky insulators to remain until the following Sunday and we know of certain ones that have been permitted to remain in use over a month. They usually char the insulator pin, but cause no further trouble. I would imagine it a very unsafe proposition to attempt to mix up in any manner with high pressure lines when they are working up to a voltage—our potential is 11,600 volts. Lightning and the combination of small boy and barbed wire fencing are our only source of annoyance or trouble."

However reluctant managers are to change insulators on live lines, it is evident that this reluctance is due solely to the personal danger attending the work of changing, and as the method about to be described is designed to eliminate such danger, it proves of interest. The method is due to Mr. Wm. B. Jackson, of the Peninsular Light & Power Company, of Detroit, Mich., who in describing it, states:

A 750 HORSE POWER PRONY BRAKE.

"The method I use in changing insulators upon the 10,000-volt circuit is extremely simple, but, at the same time, quite safe, if due precautions are taken to have the apparatus dry.

"We use a 30-foot ladder, in two parts, so as it can be made of the proper length to catch the cross arm. At the upper end a small board is put on, having a hole in it of the right size to fit on the end of the cross arm. For the ladder to stand upon we have a platform 30 by 30 inches square, having a lower part which has a pin with an insulator at each corner and an upper part which fits upon the insulators in the lower part. This upper part has two recesses for the feet of the ladder to fit in. When the ladder is in place, someone goes up and screws a small hand-vise upon the cross arm. The hand-vise is of iron and has a piece of copper wire soldered to it. This wire is touched to the line wire upon which the broken insulator is located, and if everything shows all right, is wrapped around same. A three-foot stick boiled in paraffine is used in first touching the wires together. When the grounding wire is properly on, the man goes to work with bare hands and changes the insulators, when the grounding wire is taken off and the clamp removed.

"With a plant such as we have, it is an absolute necessity to be able to change the insulators at any time. The only time we can shut down without causing our customers trouble is between 3 and 4 p. m., on Sundays, and a bad insulator cannot be left from Monday till Sunday; at least, should not.

"We have not found it necessary to take the voltage off any portion of the system for two months and fourteen days."

Part iv

A PRONY BRAKE EXPERIMENT.

In making the test of the Girard water wheels installed in the power house of the Power Development Company of Bakersfield, Cal., it was deemed advisable to measure the output of the wheels direct without reference to the generator with which they were direct connected and although it was not believed that it would be possible to absorb 750 horse-power by a prony brake, under the conditions which existed, it was thought best to try the experiment at all events.

The wheel upon which the brake was applied was the Girard governor wheel located on the shaft as shown in the illustration. It is 6 feet in diameter, having a 10-inch-crown face, and ran at 257 revolutions per minute. The manner of rigging up the brake is clearly shown. The lower horizontal arm was something over thirteen feet in length from the center of the shaft to the center of the bearing on the scale, the length selected being such that a pressure of 1½ pounds on the scale represented one horse power of work done by the water wheel.

No water could be used for cooling purposes on account of the surroundings, hence the heating effect was excessive, and owing to the heavy section of the rim of the wheel, it became impossible to conduct the heat away or to dissipate it in any manner.

The experiment proved a failure, however, because of the burning of the wooden shoes. While this result was foreseen as probable, as stated, it was hoped that the heat generated in the small time required for a trial would not be of too great an intensity to render the apparatus inoperative. So much time was, however, required to handle the brake in adjusting the water wheel to the proper load and speed, that sufficient heat was generated to char the brake shoes to such an extent as to render them totally unfit for service. The spectacular effects of the experiment were startling, for with the scream of the brake, the spitting of fire and the viscious smoking of the timbers, the scene was one ever to be remembered.

Had water been available, or rather had it been possible to have applied water to carry off the heat generated, no trouble would have occurred, as a similar brake has since been used at the same place with water applied and fine results obtained. In this latter experiment, 125 horse-power was absorbed from a pulley having a diameter of 18 inches, with a 12-inch face.

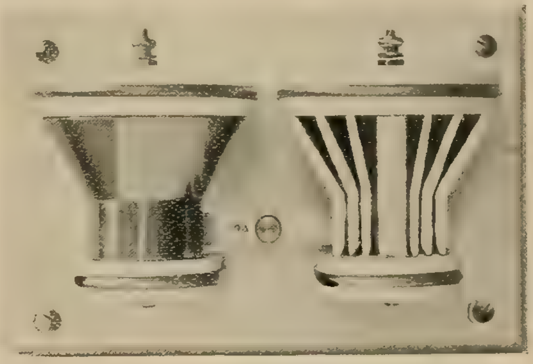
Part v

A NOVEL LIGHTNING ARRESTER.

The Stanley Electric Mfg. Co. of Pittsfield, Mass., have always borne a reputation for originality of design, and the new "S. K. C." Lightning Arrester shown will in no wise detract from this reputation. This instrument is brought forth as the result of many experiments and with an appreciation of the successes and failurees of the past. The one illustrated is of the indoor type, mounted on marble, the right hand set of cylinders having been cross-sectioned for the purpose of showing the construction.

Briefly, the arrester may be described as consisting of a nest of four concentric cylinders of non-arcing metal, the inner one being solid and the three surrounding ones hollow with "flaring" or conical tops. These cylinders are held in position between two perforated plates of vitrified porcelain provided with grooves in which the cylinders rest. The whole being securely clamped together by screws passing through the porcelain plates into the centre cylinder. The outer cylinders of each pair of arresters are connected by a brass bar, to the middle of which the ground connection is made; the line connections being made to two terminals which also serve to hold the upper porcelain plates in position.

The arrester, as shown, is a 1000 volt double-pole unit and in operation the two legs of the lines are connected to the upper terminals of the innermost cylinders, the ground connection being made to the cross bar attached to the outer cylinders of each pair. When the potential of the line is increased by lightning, the charge is met in the arrester by three spark gaps formed by the annular air spaces between the four cylinders and on reaching the outer cylinder escapes harmlessly through the ground connection. To provide against the maintenance of the arcs, a feature which has heretofore been so disastrous to lightning arresters, openings in the porcelain plates have been provided. These being placed so as to be opposite the annular air space or spark-gap between each cylinder, a draught or current is formed by the air which has been heated by the arc, and the latter carried up, by this means, to the rapidly widening gap is instantly and effectually dispelled; thereby preventing any escape of the line current to the ground. This feature is an important one and provides an unfailing "blow-out" arrangement similar to that of the magnetic blow-out which forms an important part of most modern direct current arresters.



INDOOR TYPE.

In the types of alternating current arresters heretofore on the market, cylinders or balls have been used, and as the discharge will always occur across the shortest gap, it will take place along a single line or element with the use of smooth cylinders, from a number of points with the use of knurled cylinders and from a single point where balls are used. After each discharge the surfaces of discharge become oxidized or blackened which introduces a high resistance and impairs the usefulness of the arrester, causing the lightning to take a path of higher resistance, the usual practice, when this occurs, being to turn the cylinder or balls after each discharge in order to present a new surface. In the "S. K. C." Arrester, the cylinders being placed concentrically and the discharge occurring between any one element or line of the cylinder, there may be said to be an infinite number of paths provided for it to take, doing away entirely with the necessity of turning or disturbing in any way the cylinders.

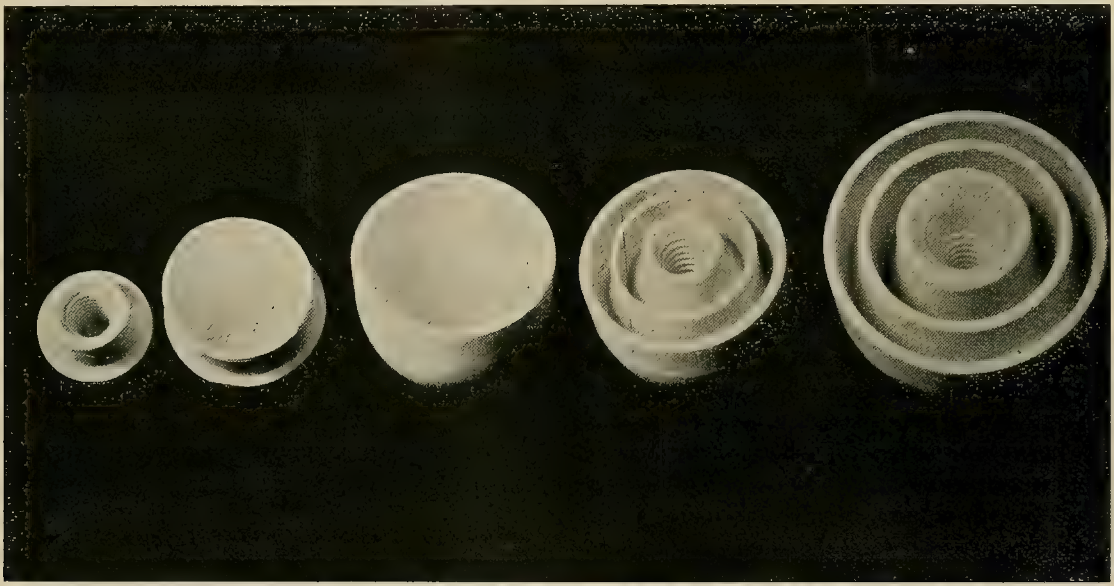
The "blow-out" arrangement also effectively prevents the fusing of the spark gaps which has been so destructive and not by any means infrequent in other types of arresters.

These arresters are capable of being arranged in groups for any line voltage. The indoor type is highly finished and mounted on a polished marble base, the outdoortype, in addition, being provided with a neat iron case and arranged to be hung on poles, where they are installed along pole lines, or in any other convenient place.

Part vi

A MULTI-GLAZE INSULATOR.

It has been pointed out in papers read before the Pacific Coast Electric Transmission Association to the effect that the puncture resisting properties of a porcelain insulator for use on high potential lines depends largely, if not entirely upon the quality of the glaze with which it is covered and the thoroughness with which this glaze is applied. Some have contended that inasmuch as an insulator with chafed or damaged glaze is liable to absorb moisture and break down, the glaze alone constitutes its chief insulation and that to it, and not to porcelain must be attributed the puncture-resisting properties of the modern porcelain. Others, in admitting that this is so, go a step further and contend that inasmuch as glazing is but merely a coating of glass, why not make the insulator entirely of glass and be done with it. But the porcelain insulator is too strong a favorite to be supplanted with glass or any other material without a struggle and it must be admitted after reading the description of a new porcelain insulator, published below for the first time, that the insulator of ordinary form may be vastly improved upon and even made to closely approach the glass insulator as a puncture-resister without losing any of the advantages which porcelain possesses.



THE BOCH MULTI-GLAZE INSULATOR.

The Boch porcelain insulator for extremely high transmission voltages is made in three shells of porcelain of such sizes that one fits closely into the other and, after being cemented together, forms a solid insulator closely resembling the ordinary procelain type in outward appearance. These three shells are glazed outside and inside most carefully, hence when they are put together and solidly cemented by a thin layer of melted glass, there are intervening between the wire and the pin, six skins of glaze and two layers of glass. In marked contrast to this is the ordinary insulator having but two skins of glaze between the wire and the pin.

The advantages of the Boch insulator are manifest. It retains all the merits of porcelain as an insulating material; it is as impossible to puncture it as it is impossible to puncture glass, for, as is also the case with glass, extremely high potentials jump over the surface of the insulator to the pin rather than go through it. Moreover, injury to the glaze ruins a porcelain insulator of the ordinary form, while with the Boch insulator, should the outside shell absorb moisture, the two layers of glass, together with the remaining five layers of glaze, will unfailingly prevent the passage of current from wire to pin, in addition to making it absolutely impossible for the moisture to penetrate beyond the outer shell. It is surprising, too, how solidly the glass, to all intents and purposes, cements the three shells together into a single solid insulator. In the half-section illustrated, a six-inch insulator was split down from the groove on top by a cold chisel as effectually as though it were of solid porcelain.

The cuts herewith were made from sections of the Boch insulators kindly loaned for the purpose by the California Electrical Works, San Francisco.

Transmission

AN ANSWER TO MR. SUTCLIFFE'S QUERIES.

By Alexander Jay Wurts.

THE papers on "Protection Against Lightning," in the November issue of the Journal of Electricity are exceedingly interesting and offer substantial material for reflection and study.

Referring to the five inquiries at the end of Mr. Sutcliffe's paper: The occasional sudden changes in speed of generators, together with the violent fluctuations of current and e. m. f. at the moment of a lightning discharge, justify in a measure the questions which have been proposed. I would not, however, explain any of these phenomena by the "damming back of a current."

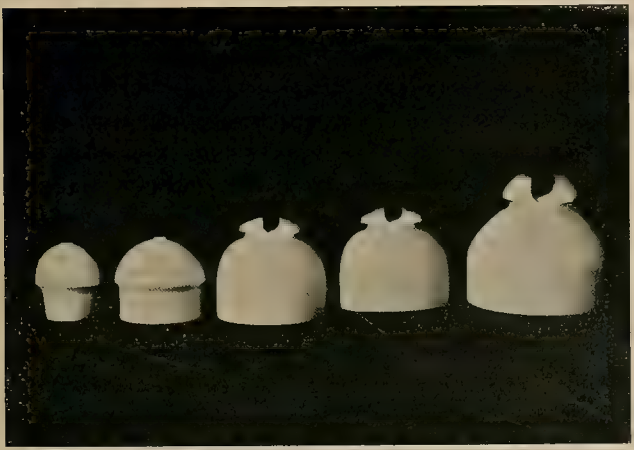
A sudden falling off in speed is, I think, sufficiently explained by a short circuit.

A sudden increase in speed is explained by a sudden decrease in the load.

A marked rise in potential in the system can be produced by switching, particularly under light load conditions, or by the melting of a fuse.

The rise in potential is due to the well known phenomenon of field discharge from the converters.

My experience leads me to believe that static discharges from overhead wires are seldom of sufficient strength in amperes to melt fuses of any considerable size. When the wires are actually struck by a lightning discharge, which is a very rare occurrence, the fuses are liable to be melted. Ordinarily, however, the discharges are exceedingly minute, as compared with lightning and are easily comparable to discharges from a large battery of Leyden jars.

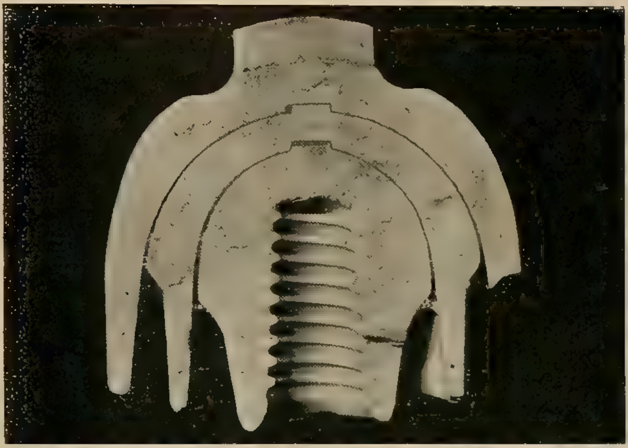


ELEVATION OF PARTS OF THE BOCH INSULATOR.

The rise of potential, which as explained is due to "field discharge," and which has given birth to the idea of a "damming back of the current" and a "bursting effect" like the sudden shutting off of water under momentum in a pipe, will undoubtedly strain the insulation and may not infrequently be the cause of mysterious breakdowns. But danger from a rise in potential is not comparable to the danger from a surging static charge in the line wire.

The relative danger of lines traversing an elevated portion of the country and to those which lie lower, is a question which I have made the subject of a series of experiments covering two seasons. The results of my observations have led me to believe that there is no marked difference.

The question as to whether there is any feasible, simple method of protecting transformers scattered over a distributing system, would seem to indicate that protection on distributing systems has thus far proved a failure. Although accidents will happen, still I am of the opinion and believe that the average experience will bear me out in this statement, that an effective form of lightning arrester connected and carefully grounded to every 1000 feet of wire, will prove a perfectly feasible, simple and highly effective method of protecting high grade, that is, well insulated apparatus on distributing systems. I would define as an effective form of lightning arrester, one that will offer a relatively low resistance to the passage of static discharges.



SECTIONAL VIEW OF THE BOCH MULTI-GLAZE INSULATOR.

I trust that the above will sufficiently answer the questions that have been brought forward.

Correspondence

ACETYLENE AND TRANSMISSION INTERESTS.

To the Editor:—I notice in the issue of the Journal of Electricity for October last, an extract from a German paper which discusses the explosiveness of acetylene.

The gas trusts have been working this explosive business for all that it is worth, and the impression seems to have gone abroad that acetylene is also a menace to electrical interests. I am inclined to believe that with all the maligning influence of the gas trusts, acetylene gas is going to come to the front in the very near future and I also believe that so far as electric transmission plants are concerned, it will not prove a menace to them in this State, owing to the great distance from the source of manufacture.

I have investigated the subject to some extent and I am inclined to believe that the greatest use to which electric power will be put in California in the not-very-far distant future, will be in all sorts of electro-chemical and electro-metallurgical purposes. I believe furthermore that we are entering upon a new field of industry in this line and that the development of our vast water power resources will be called upon largely for such purposes as those above named.

J. S. E.

Transportation

THE MOUNTAIN RAILWAYS OF SWITZERLAND.

By A. Van der Naillen.

CONSIDERABLE interest attaches to the development of the electric railway in Europe for the scaling of high mountains. These roads are principally in Switzerland, where tourist travel is immense, so great indeed, that as many as half a million tourists often cross certain points of interest in a single day. It is well known that Switzerland is the ideal country for water power because of the innumerable waterfalls that forever descend from the eternal glaciers. Electric power is most advantageous for this class of work on account of lightness, as compared with the steam locomotive, its economy of operation from the water powers, its freedom from smoke, soot and cinders, and its popularity with the general public. For these reasons electric traction has been adopted as the motive power for all roads recently constructed, in process of construction, and projected in the region of the Alps.

The line of Burgenstock, near the Lake of Lucerne, reaches a height of 2600 feet in a distance of 2700 feet, the grade being from 32 per cent to 38 per cent. The cars are propelled by a cable operated by electric motors, the power house being over two miles from the railway. This power house contains a 300 horse power turbine which drives two dynamos connected in series and giving a potential of 1600 volts for transmission by bare wires to the summit of the road, over two miles distant. At the summit is the motor house, containing two motors, running in series with each other and the line, and driving drums upon which the cable is wound. The cable draws up the cars at the rate of two miles an hour.

Two other electrically operated mountain railways of Switzerland are those at Strauserhorn, also near the Lake of Lucerne, and which ascends 5000 feet in a distance of a mile and a half with grades from 30 per cent to 62 per cent,—the power house being two miles distant—and the electric railway which scales Mount Salvadore. This mountain rises alongside the Lake of Lugano and the road reaches about the same altitude as the railway of Burgenstock, just described. The Mount Salvadore road, however, has grades of from 17 per cent to 60 per cent, but it is divided in two sections so arranged that while one car is descending, another car is ascending on the other section. This road is also operated by cables wound on drums as in the Burgenstock road, but the power house is about three miles distant from the motors.

The most important mountain railway now under construction is that by which it is proposed that tourists may ascend the famous Jungfrau with ease. This Jungfrau road will reach an elevation of 12,500 feet and its length will be six miles, of which five miles will be in tunnels. The last station will be underground exactly below the summit of the Jungfrau and from there and upward the shaft will be built two hundred feet high to the very summit, whither the tourists will be hoisted by an electric elevator. These are some of the principal electrically operated railways being built in Switzerland, and their attractive features draw millions and millions of tourists to that country each year. These railways have proven good investments.

If we do not do so, will not our children attract further tourist travel to California by inaugurating a series of similar improvements in our incomparable Yosemite Valley, or through King's River Canyon, or up Mount Shasta?

Traction

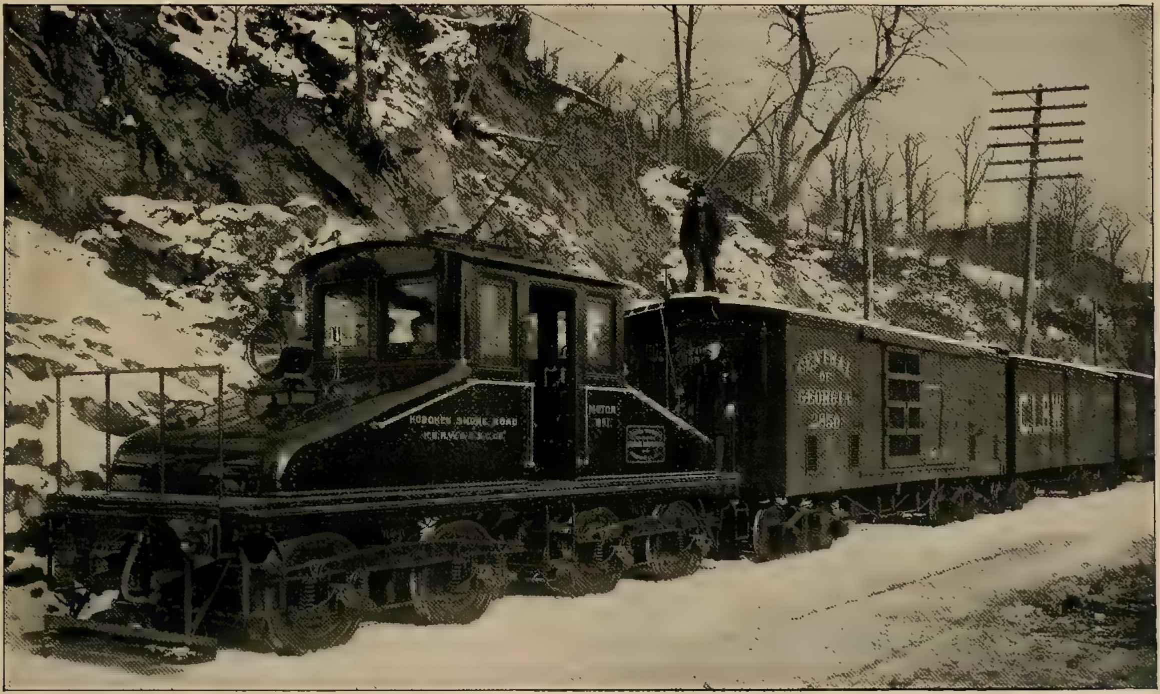
SUPPLANTING STEAM WITH ELECTRIC TRACTION.

ANOTHER step forward has been taken in the use of electricity for switching purposes on the steam railroad, in place of the noisy drill steam engine. This time it is on the Hoboken Shore Road, Hoboken, N. J., the full name of which is the Hoboken Railroad Warehouse & Steamship Connecting Company, and the line runs from Seventeenth St., Weehawken, to Fourth St., Hoboken, along the water front, or from the Erie tracks at Weehawken to the docks of the North German Lloyd Steamship Co., Hoboken, a distance of about two miles.

This road was opened for traffic on September 20th, 1897. It was constructed to provide connecting facilities between the tracks of the railroad companies entering Hoboken and the numerous warehouses and docks which line the West side of the North River from Hoboken to Weehawken. It is double track over a private right of way from Seventeenth to Fourteenth Street, single track down Hudson Street to Eleventh Street and double track along the River Walk to Fourth Street.

The switching of the cars for the past three months has been effected by a repair car of the Hudson County Electric Railroad Company. The new locomotive was put into regular service on the 4th of January, 1898, hauling trains of loaded and empty freight cars between the docks and the Erie track. The difference in its operation from that of the common drill engine is immediately noticeable. The electric locomotive responds instantaneously to the movement of the controller handle and starts without jerk or noise, tightening up the couplings uniformly or coupling the cars together so gently that no blow is perceptible.

The locomotive was constructed in the shops of the General Electric Company, at Schenectady, N. Y., and somewhat resembles in appearance the electric locomotive in use on the Manufacturers' Railroad, which connects with the N. Y., N. H. & H. R. R. tracks at New Haven, Conn., and the giant locomotives now handling the entire freight traffic of the Baltimore & Ohio Railroad, through the Belt Line Tunnel at Baltimore. It is mounted on two four-wheel trucks, each axle carrying a General Electric 2000 motor, giving the locomotive a total of 540 rated h. p. The weight on the drivers is 57,200 pounds; the draw bar pull is 10,000 pounds. The locomotive is driven through a single reduction gear of very low ratio. The speed is correspondingly low, and is rated at eight miles an hour when hauling a heavy load.



THE HOBOKEN ELECTRIC LOCOMOTIVE.

At each end of the locomotive is an automatic coupler, and a small railed platform for the brakeman in charge of the trolley pole. The cab is of iron and resembles a double steam locomotive cab, with a sloping tender shield at each end. Drop windows are set around the four sides of the cab, affording an unobstructed view in all directions to the motorman. A sliding door at each side gives admission to the locomotive. The interior of the cab is lined with cherry and is a spacious and well lighted room. The fittings are all of polished brass or nickel. On each shield is a head-light; in addition, one shield carries a bell, the other a chime whistle. Beneath one of the shields are four packed card resistances, two sand boxes, the compressed air tank and the equalizing air tank; beneath the other are eight resistances, two sandboxes and the engineer's tool box. At one end of the cab is placed a controller of the series parallel type known as the L-2. It contains, of course, the magnetic blow-out and is arranged to operate the motors, either four in series or each two in series-multiple. Besides the controller is the air brake handle and the two valves of the sanding arrangement by means of which the sand is blown by the compressed air under the wheels.

In front of the motorman is an air brake gauge and above it an ammeter reading to 500 amperes. Fastened to the roof of the cab is an "L" automatic circuit breaker set at 500 amperes. On the other side of the controller, from the motorman, is an "M" circuit breaker and an automatic governor switch for the air pump, placed at the other end of the cab. This is a single cylinder pump driven by a 3 h. p. iron clad bipolar slow speed motor, and the operation of the air pump is automatic. When the air in the tanks is at normal pressure the governor-switch is opened, but blowing the whistle, applying the brakes or using the sander causes the pressure to fall, which closes the switch automatically and starts the motor and pump. The cab is lighted by five standard Edison railway incandescent lamps.

The overhead wire is No. 00, suspended from wires strung between octagonal cedar poles, except at two or three points, where bracket construction is used. Where the locomotive turns in from Hudson Avenue to the River Walk, a peculiar condition has caused a special method of bracket construction. It was necessary for the overhead line to be so set as not to infringe upon the limit of the next property. Thus at this point the overhead line is suspended from two bracket arms, one 6 feet and the other 18 feet long. The current for the road is taken from the station of the Hudson Electric Light Co.

Continued on page 83.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity, Gas and Power.

OFFICIAL ORGAN OF THE PACIFIC COAST
ELECTRIC TRANSMISSION ASSOCIATION.

Subscription Payable in Advance. Terms—Domestic, One Dollar
per Year: Foreign, Two Dollars per Year.
Rates for Advertising on Application.

The trade supplied by the San Francisco News Company.

EDITED AND PUBLISHED BY GEO. P. LOW.

Business Office, 516 COMMERCIAL ST.
Telephone, Steiner 63.

Address all communications to
Editorial Rooms, 427 TENTH AVE

SAN FRANCISCO, CAL.

Entered as Second-class Matter at the San Francisco Postoffice

Volume V. JANUARY, 1898. Number 4

EDITORIAL.

THE TENDENCY OF ELECTRICAL PROGRESS.

The Electrical World, (Vol. XXXI, No. 1,) in an interesting review of the present tendencies of electrical progress, points out that the evolution of the electric arts from their small beginnings, a half century or more ago, has been a singular story of progression, first along one line and then another, changing, as the accumulation of knowledge crystallized into coherent theories of electrical action, into a more purposeful growth. To-day the development of the heavy-current applications seems to be on the eve of transition—apparently returning to the simple principles of the very earliest days, and discarding much that was the product of hard study and harder labor in its perfection.

When the first dynamos were built it was found necessary to introduce a device for straightening the pulses of current that flowed from their armatures first in one way and then in another, into an orderly current, something like that given by Volta's pile or Galvani's "Crown of Cups." The commutator was invented, elaborated, and, after much travail, perfected as far as such a thing could be perfected. Electricians viewed the chaotic currents emanating from the whirling wire with disfavor. They would not energize an electromagnet, they would not work a telegraph, so the commutator was called into being to rectify them. Later, when motors had progressed beyond the stage of scientific curiosities, commutators were used upon them to again distribute the straightened current into its elements.

Henry and Farraday had found out that pulses of current induced others in neighboring conductors. Ruhmkorff had made the secondary conductor long and coiled it many times about the primary. Finally somebody reversed one of his coils and found that "intensity" currents could be made to give "quantity" effects, as well as vice versa. This was the first step in the progress of the alternating current. Jablochkoff and Gaulard and Gibbs and others of that day worked out a system of alternating-current lighting, while Siemens and Von Alteneck made dynamos that were the medical magnetic shocking machines of former days grown to larger proportions. From these small beginnings, by slow steps at first, the modern alternating and polyphase systems have sprung.

To-day the commutator is sinking slowly into comparative obscurity. A new race of dynamo mechanism has grown up, commutatorless, of the original simplicity of the sine-wave current. It is a return to first principles, a going back to the current conditions that puzzled and appalled the early experimenters, and caused them to devise the rectifying sliding contact machine that has given such a world of trouble ever since. Who is there to-day who shall say that the direct current is the normal variety or deny the alternating its claim at least to priority of origin? At best turning it into direct current was a makeshift resorted to in the early days, because it was not then known how to utilize it in its original simplicity. Happily we are now learning how, and the obvious and manifold advantages of the alternating current are beginning to be appreciated.

It is in this direction that one of the most evident tendencies of present progress is directed. The great lighting stations are changing over from the complex methods formerly in vogue, to the simple and satisfactory polyphase system of generation and supply. Long-distance power transmission is a commercial possibility only for the alternating current. The last stronghold of the direct curent, the railway, is now being invaded by its rival, and before many more years shall have passed the applications of direct current will be restricted to those uses for which it alone is fit. Even the one advantage of the direct current, long contended for, the possibility of its use in connection with accumulators, is nullified by the rotary converter.

There is no other tendency so conspicuous as this. The substitution of alternating for direct-current methods is becoming more and more widespread. The great installations now under construction are practically all of the alternating type. In railway work the day cannot be far distant when the commutator motor will be regarded only as an evil memory. Even in telegraphy and telephony the alternating current is coming into use. Such to-day, seems the most marked direction of advance in the electrical field, and no doubt ensuing years will see the practical disappearance of much of the direct-current apparatus now used for many purposes.

The trend of electrical development indicates that the Pacific coast is destined to play a conspicuous part in the new order of things because of the great activity evidenced in the erection of electrical transmission plants. The incentives for pronounced progress in this direction are due solely to natural causes—to the presence of abundant water power and to the absence of low priced fuel,—and there is but little room for doubt that the attention of the electrical engineering world will be always more than interested in the epoch-marking projects and experiences that will ever be found in the far west. It is these plants that embody the greatest advances in alternating current work, which is symbolic of the highest state of electrical development, and it is by such organizations as that of the Pacific Coast Electric Transmission Association that the greatest detail in the story of the new advance, is to be recorded.

THE FIRST CENTRAL STATION.

In November last, the London Electrical Review celebrated its twenty-fifth year of publication in a special number of unusual merit, and among the valuable contributions to that issue is one from Mr. Robert Hammond, M. I. E. E. on "Twenty-five years' Development in Central Stations," that virtually raises the question as to which central station belongs the credit of being the very first to sell electricity to the general public as a merchantable commodity. It is believed that this distinction belongs to San Francisco in the enterprise inaugurated and prosecuted to a successful issue by the late George H. Roe, who brought about the incorporation of the California Electric Light Company on June 30th, 1879, and at once commenced the building of the plant for furnishing electric light to the public.

The career of Mr. Roe, who died in Brooklyn, N. Y., on December 10, 1894, is so closely interwoven with the first development of central stations that it possesses unusual interest. When the California Electric Light Company was organized, the appliances that had been developed for the generation and application of electricity were most crude. This and the absolute novelty of the scheme of electric lighting made it almost impossible to induce capital to embark in any electrical enterprise, and it was with the utmost difficulty that Mr. Roe,—who was himself at that time a man of limited means,—prevailed upon a sufficient number of his friends to incorporate a company to introduce electric lighting in San Francisco. He finally succeeded, however, after a display of that indomitable energy which was a part of his nature, in getting together sufficient capital to install a plant, the capacity of which was limited to a small number of arc lamps. For several years the income of the company was wholly insufficient to pay the expenses which were incurred, and in order to raise the moneys necessary to keep the enterprise alive, assessments were resorted to. Some of those who had associated themselves with the business did not have sufficient faith in it to pay the calls made upon them; one by one they retired, and it seemed for a time as if the money which Mr. Roe had invested himself and had induced his friends to invest would prove a total loss. He had great faith in the future of electricity as an illuminant and as a motive power, and never doubted for a moment his ability to demonstrate its desirability and practicability for those purposes, if he could succeed in keeping his struggling enterprise alive.

After three or four years of reverses and hardships the business began to assume more importance; one small dynamo after another was added to the plant, the lines of the company were extended from time to time, so as to cover additional territory, and in a few years business men came to realize that the California Electric Light Company was no longer an experiment, but a success and while others rendered assistance in the accomplishment of this result, it is not unfair to them to say that to Mr. Roe is due the principal credit of the success which the California Electric Light Company achieved.

In 1891—the business of the California Electric Light company being confined almost exclusively to arc lighting—Mr. Roe fully realized, and endeavored to impress upon his associates the importance of installing and operating an incandescent plant in San Francisco. The Edison incandescent system had been introduced in several of the cities of the United States, and had proven so successful that he realized not only the importance, but the almost imperative necessity, of the California Electric Light Company, or the people controlling that corporation, of acquiring the Edison rights for San Francisco. He sounded his associates, some of whom did not receive his suggestions with favor; but feeling that his course was the right one, he took upon himself the responsibility of making a personal contract with the Edison Company. The directors of the California Electric Light Company, after a thorough investigation into the value of the rights which he had secured, accepted and approved his contract, and out of this arrangement grew the organization of the Edison Light & Power Company, in 1891, which has since been succeeded by the present San Francisco Gas and Electric Company.

An incident in the early efforts of Mr. Roe to establish the pioneer central station of the California Electric Light Company, is told in the following excerpt from a personal letter addressed by Mr. Roe to the writer:—

"The California Electric Light Company was incorporated June 30th, 1879. At that time electric lights had been in use in mills and factories, where the power was available, but no building had been put up in any city for the purpose of distributing light throughout the city. Our people, that is to say, the writer, and other incorporators of the company, being unable to obtain any information regarding the business of electric lighting because no electric lighting had been done, determined to ascertain whether the business of renting lights could be made profitable; and for that purpose built a station, if station it could be called, for the purpose of ascertaining: First, whether it was practical to distribute lights throughout the city to the different people; and second, whether the people would take these lights and pay a price for them that would show a profit.

"Naturally, the cheapest building was constructed, simply 4x4 uprights, a wooden floor laid on the ground, the sides of the building covered with sheet iron; and the building itself in the rear of where the Flood building now stands and the entrance to which was through a tunnel. The boiler, engine, dynamos, oil house, coal-pile, and everything was huddled together in this one enclosure—as I said before, as cheaply as it was possible to do it. We realized at the time that the expenditure we were then making was merely experimental, and would be of no value if the business amounted to nothing.

"The machinery was stopped at midnight; no watchman was engaged; the building was in the rear, so that it could not be seen from the street; and we have never been able to determine whether, in raking out the fire before shutting down, some coals were left on the floor, which was saturated with grease, or whether some tramp came in to lodge; but we do know that on the morning of April 24th, 1880, the fire took place. The apparatus was damaged of course, but we congratulate ourselves that the fire took place when it did, because we otherwise would probably have made temporary additions to the building, and would not so soon have constructed a proper station. There was no insurance on the building; we did not ask for any. We were making an experiment, and we realized what we were doing.

"The engine that was in that fire is now (September, 1892) in use in our Station A; the boiler that was there used is also in use in Station A; of course, having new tubes and other repairs. Some of the dynamos that were there in use, that came through the fire, and were destroyed so far as ninety-nine dynamos out of a hundred are destroyed by fire, were repaired by ourselves, and are now and ever since have been in use in our Station A, and practically as good as though the fire had not occurred. The repairs to them simply represented the wire and labor of winding, less the amount we received for the old wire taken

The claims of Great Britain for the distinction of being the country in which the first central station was installed, appear to be settled in the paper of Mr. Hammond, heretofore referred to, which states that "the honors of the title of 'first central station,' in the United Kingdom must be divided between the Holborn Viaduct and Brighton Works, both of which were established in the year 1882." The Holborn Viaduct station was started, states Mr. Hammond, early in 1882 and went out of business in a year or two. The Brighton station was inaugurated in February, 1882, and in 1894 its business was absorbed by the Brighton Corporation.

The Brighton station in England, and the California Electric Light Company's plant in California, appear therefore, to occupy analogous positions in that they were pioneer stations which have become permanent institutions, though having been absorbed into other industries. The priority, however, undoubtedly rests with the San Francisco station, and now, it may be asked, is there any electric central station in the world that can antedate its organization—June, 1879,—or its actual operation in the summer of the same year?

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

REMINISCENCES OF EARLY ENGLISH STATIONS.

The contribution by Mr. Robert Hammond to the quarter-centennial edition of the London Electrical Engineer also contains many interesting references to the earliest experiences in electric lighting in Great Britian and the article throughout forms very entertaining reading. Truly many of the "old-timers" will recall parallel experiences to that cited by Mr. Hammond who states:

"Cockermouth was the site of an early central station, this being put down for the public lighting of that town in 1881. I had undertaken this contract, and in the dearth of capable assistants that then reigned, I was at my wit's end to know who to send to superintend the work on the spot. At this juncture a man entered with a letter of recommendation of a flattering nature. 'Could you go to Cockermouth by the 3 o'clock train,' I asked. He replied in Yankee drawl, 'Waal, I went to Singapore at four hours' notice, and I guess I could to Cockermouth at five.' Whereat he was dispatched and for some weeks we were in receipt of glowing reports of progress and applications for funds. On the eventful opening night excursion trains ran in from all parts of Cumberland, and the town was en fete. A switchboard was arranged outside the building so that the switching-on could be done in the sight of all the people. Mrs. Whittle, of Whitehaven, stepped forward to operate the switch, but alas, no light came. When they sought for the 'electrician' it was found that he had decamped, leaving a goodly amount of debts unpaid, and the arc lamps all connected up the wrong way. The crowd took the fiasco most good humoredly and amused themselves by parading the streets with lighted brooms dipped in tar, shouting "The only genuine Brush light."

Then again the observation of the builder of Kensington Court, "strikes home" to the pioneer when, in discussing the works laid out by Mr. R. E. Crompton for the lighting of Kensington Court remarked: "You electricians seem ready to supply everything connected with electricity except LIGHT. I can get any number of dynamos, engines, patents and lamps, but what I want for my buildings is LIGHT."

Of amusing, though in part pathetic, interest, is the reference made to Gaulard, to whose genius the original conception of the transformer is due.

"The development of electric lighting in London was largely assisted by an enterprise, the fortunes of which have been of very peculiar variety. In 1885, Sir Coutts Lindsay laid down an installation in Bond street to light the Grosvenor (picture) Gallery, and being applied to by some of the neighboring tradesmen, he turned his attention to public supply by means of overhead wires. The system of distribution was quite novel, then known as the Gaulard & Gibbs system, and now as the Alternating Current Transforming system. Poor Gaulard, the patentee, who afterwards died in a madhouse, was a most excitable enthusiast, and at one point of his carrer he certainly imagined that in his "Secondary Generator," as he termed it, he had solved the perpetual motion problem. I remember his calling upon me at the time of my conducting some experiments with the first Ferranti Alternators under Cannon Street Railway arches, and declaring that with the semi-portable engine that we had there he could light the whole of London. He denied that the utilization of the converted current had any effect upon the generating plant, and I at once suggested that it would be useful to fit up 100 E.H.P. of transformers in the arches, and run the alternator without the intervention of the engine. This sarcasm failed to shake his ideas, possibly because in my French it was somewhat veiled. However, his claims were so ludicrous that I declined to have anything to do with his system, a refusal which I afterwards had occasion to regret. Sir Coutts Lindsay made the first practical exhibition of it, but it went badly until, on the advice of Lord Kelvin, Mr. S. Z. de Ferranti was called in. He found the converters working in series and at once changed them to parallel working, which immediately proved highly successful."

SUPPLANTING STEAM WITH ELECTRIC TRACTION.

(Continued from page 79)

The dimensions of the Hoboken Locomotive are: Length over all, 29 feet; width, 8 feet; height over trolley stand, 13 feet; wheel base, 5 feet, 6 inches; truck centers, 12 feet, 9 inches; weight, 57,000 pounds.

The trial trip of this locomotive was witnessed by representatives of all the railroads having offices or termini in New York and New Jersey. The locomotive was coupled to eight loaded freight cars with an aggregate dead weight of 295⅝ tons, which it handled with ease. It was then coupled to a number of passenger coaches and the party made the journey over the line from Hoboken to Weehawken and back.

At the luncheon which followed, two interesting speeches were made. Mr. F. Le Bau, General Freight Agent of the West Shore Railroad, pointed out emphatically the usefulness of such a road as the Hoboken Shore Road in facilitating the transport of merchandise directly from the steamships to any part of the country, and of the rapid switching electric locomotive, by means of which the freight cars could be handled more easily and more expeditiously than with the ordinary steam drill engine. Mr. W. J. Clark, General Manager of the Railway Department of the General Electric Company, in an interesting talk full of reminiscences of the early days of the street railway struggle, said:

IN THE CAB OF THE HOBOKEN ELECTRIC LOCOMOTIVE.

"Ten years ago, the development of three things made electric street railways practicable and profitable. These were the under-running trolley, the carbon-brush, and the modern method of motor suspension. The development of three other things now renders the general application of electricity to standard railroads both possible and probable. These are the safe breaking of heavy currents, high voltage for their transmission and methods for their application to almost any load on any portion of a line. Other features are being developed that will seriously affect the result; not the least is the Sprague system of multiple and unit control, increasing the flexibility of the already most elastic of all transportation agents, and while the economy of electricity has already been thoroughly demonstrated in performing the same service as by steam or animal traction, so far as passenger service at least is concerned, something beyond the mere question of economy has now to be considered, to wit: accomplishment by electrical methods of what would be entirely impossible with steam. The first steam railway man within my range of acquaintance to fully grasp this idea, is Mr. John Jundie, Consulting Engineer of the Illinois Central Railroad Company, who has set a pace on acceleration that would not have been dreamed of two years ago, and the schedule which he has mapped out for the contemplated electrical equipment of the suburban lines of his company involves a rate up to 40 miles per hour in 20 seconds. That this is practical has already been demonstrated. In fact so high a rate of acceleration has been made as 43½ miles per hour in 20 seconds, so that the practicability of Mr. Lundie's plans have been thoroughly demonstrated. This for passenger service.

"In another direction even greater changes may be prophesied which will come from the adoption of electricity in standard railroading, viz: the lengthening of freight trains and the consequent reduction in that most important feature of operating expenses—transportation wages. The advantages of electricity will have so thoroughly demonstrated themselves in the directions suggested that instead of main steam lines with electric feeders, in ten years it will be a question of electrically operated main lines with steam feeders through the sparsely settled districts, and a more extended system of suburban electric roads in densely populated districts also feeding the main lines.

"The electrical engineer has much to learn from the steam railroad man and must constantly rely upon him for suggestions as to the best methods of making practical applications of electricity. The American transportation man and the American electrical engineer should go hand in hand, continuing to lead the world as they now do in all transportation problems. The American engineer has won conquests abroad as well as at home, not the least is the solution of the problem of electrical equipment for the Central London Underground Railway, the most important of this character that has yet been accomplished. The American engineering plans were selected on account of their merit in the face of the severest competition from every European electrical manufacturing company, and no greater tribute can be paid to American engineering methods than to state that eighty per cent of all the railway apparatus used in Europe is designed in America, so that the American engineer stands to-day head and shoulders above those of any other country. With the encouragement of the co-operation of American railroad men he is bound to revolutionize the entire method of transportation within a comparatively short space of time, so that American railroad methods will then, as now, be in advance of those existing anywhere else on the face of the earth."

THE MAKING OF PORCELAIN INSULATORS.*

By F. A. C. Perrine, D. Sc.

By most writers on the subject, the material of porcelain is considered to be one of the two great divisions of ceramic ware, and it is distinguished from pottery by being more dense, whiter and less fusible, but particularly in being translucent. Indeed, many consider that translucency is the only means by which porcelain may be distinguished from pottery. Pottery is a ceramic ware molded from a paste of impure hydrated silicate of alumina, containing certain amounts of free silica, lime and iron. The product is opaque and invariably porous, on account of the removal of the volatile ingredients in the baking process. Porcelain, on the other hand, consists principally of a pure silicate of alumina only slightly hydrated, called kaolin, inclosed within a matrix of hard silicate glass. In the oldest history of the art the Chinese found pure kaolin in certain clay banks, and in other banks the ingredients for a silicate glass, which, being mixed together, molded and baked, formed what is called "natural" or "hard paste" porcelain. This was first imitated in Europe by "soft paste" porcelain, an admixture of the kaolinic clay with an artificial glass composed of a mixture of niter, soda, gypsum and salt, the proportion of kaolin to the glass being much less than in the natural Chinese product. Between these two lie the "mixed" or "bastard" porcelain, which are uncertain in character, but which are all composed of kaolin inclosed within a bond of more or less fusible glass. To this last class belong most of the American porcelains, although some of our potteries produce a material more like pottery than porcelain in porosity by mixing the ordinary grades of pottery clay with kaolin. When first baked, all of these materials are more or less imperfect over the surface, having much roughness and little luster, which surfaces must be finally protected by a subsequent glazing, the glaze consisting of nothing more than a thin coating of glass, which may be merely and entirely an artificial glass similar to that from which bottles are made, or a natural glass made by melting over the surface a powder of pure feldspar. We see then, in the first place, that the character of the insulating material depends upon the clays used and the percentages in which they are used, since by charging the ingredients we may pass from glass, which is melted and runs at a temperature a little above the red heat, through soft paste porcelains and mixed porcelains to hard-paste porcelains, which in the hardest grades cannot be melted at a temperature below 2,000 deg. Fahr. Pottery can hardly be ranged in this series, nor is it proper to range here the so-called porcelains containing pottery clays, for the reason that the materials from which these articles are made all contain substances of a volatile character, and furthermore, these clays are deficient in fusibility, so that the ware is necessarily porous on account of the volatilization of water and other contents of the materials as they are molded before baking.

The general process of manufacture of the insulator for an electrical line follows closely the processes that have been used in the manufacture of porcelain since the earliest times, with one important change, which is the result of modern inventive methods. The clays used are intimately mixed by grinding under water into a perfectly homogeneous mass, and after the superfluous water used in grinding has been removed by settling or filtering, the clays are molded into shape required for the finished articles by either "casting," "throwing" or "pressing." The operation of "casting" is the one by means of which we obtain thin egg-shell china so much admired in our dainty teacups. For this purpose a mold of plaster of paris is furnished, which determines the outside shape of the article to be made. This mold is filled with a so-called "slip" of clay, about the consistency of cream; the plaster mold immediately absorbs the water and holds on its surface a layer of clay, the thickness of which is determined by the time the slip is allowed to stand. When the articles are thick enough, the remaining slip is poured out, the surface smoothed by a delicate touch or two and the teacup is ready for drying and baking. Larger and thicker articles have from time immemorial been "thrown" on the potter's wheel. For this work the slip of clay is settled and filtered, and the remaining mass of wet clay molded and dried until the correct plasticity is obtained, when it is taken by the potter and whirled upon his wheel, while with his hands he guides the jug into the shape desired.

Modern invention has almost superseded the potter's wheel by the potter's press, and by this press the tough hard-paste porcelain can be made in thick objects without porosity, as was formerly only possible with glass and soft-paste material. For working in the press and to obtain a material of great density, the damp clay is further dried until it is in a powder which will not adhere in masses except under considerable pressure. This powder is then filled into a matrix and a core brought down; the sharp pressure consolidates the clay into the form of the finished article, the density of the resultant baked porcelain depending not only upon the proportion of the ingredients, soft and fusible, but also upon the amount of pressure applied; since as the pressure is increased the clay may be more thoroughly dried and smaller spaces left by evaporating moisture. Moisture cannot, however, be entirely eliminated from clay until it is subjected to the heat of a pottery kiln, and that this process removes a very considerable amount of water from the mass is shown by the fact that the shrinkage in baking amounts to about as much as the shrinkage in the cooling of cast iron, namely, a shrinkage of one-eighth in the linear dimensions. The spaces remaining are filled in the baking process by the fusible material with which the kaolin is mixed.

Whether "cast," "thrown" or "pressed," the articles made from clay are of consistency not different from that of a lump of clay until subjected to the heat of a pottery kiln, when the water of hydration is driven off from the silicate of alumina and any glass contained in the mass is fused, thus rendering the finished baked porcelain article hard and solid, the hardness and toughness depending largely upon the quantity and quality of silicate of alumina, while for the solidity we must look to the presence of a certain amount of fusible glass. The proper porcelain, therefore, for insulation is that in which there is only that amount of glass present which is necessary to fill up the porosity of the dehydrated silicate of alumina, since when this proportion is attained the greatest amount of strength consistent with non-porosity is reached. Should the amount of glass be increased beyond this point the porcelain will become brittle, although it will still be nonporous—but nonporous just as glass is nonporous—and hence without the advantage over ordinary glass supposed to be possessed by a hard-paste porcelain. If the amount of glass present is only so much as will fill up the pores left by the escaping water as the silicate of alumina is dehydrated, we can readily see that such porcelain has no property by means of which wide cracks in the molded clay can be stopped up, since at no temperature available within the pottery kiln will the mass fuse and run. We may say that the glass is drawn by the porous silicate of alumina into itself by capillary attraction, and when spaces are present which are not capillary these spaces cannot be filled up; accordingly, we see that the solidity of the finished article in hard-paste porcelain manufacture depends upon the solidity of the molded clay, and we also see that it is erroneous to suppose that while the porcelain manufacturer can make thin articles which will be solid, it is impossible for him to obtain an equal solidity when heavy masses are dealt with. It is, indeed, more likely that the heavy articles will contain open spaces than that the latter be present in thin pieces, since whether the pressure is applied on the wheel by the hand or in the matrix by the die, it is easier to make solid a thin layer of the clay than a thick one, but at the same time that porcelain manufacturer who does not increase his pressure sufficiently to insure the solidity of thick pieces is not handling his clays properly, and the fact that certain makers are not able to produce heavy solid articles does not tend to prove that solidity is an impossibility where the clays are properly handled.

---

*An abstract from an article in Electrical Engineering, Dec. 15, 1897.

Another danger must also be avoided in the choice of a porcelain insulator of great weight, which is harder to detect than the presence of porosity, since the exact knowledge of the mixture of clays used is only possessed by the manufacturer himself. I am speaking now of the tendency toward the use of soft-paste porcelain by manufacturers whose machinery is not powerful enough to compress the hard-paste clay to a sufficient density for a perfectly solid heavy insulator. Of course, with what has gone before, we can at once see that should a manufacturer find that his mixture in heavy masses does not give a thoroughly solid product, he can at once add more glass, or glass of a more fusible character, reducing the amount of kaolin, on which we depend for strength. He will then obtain great solidity at the expense of toughness and strength. This is an error in the manufacture of insulators which can only be detected with the greatest difficulty, since the highest experts on porcelain wares are often at a loss to determine whether the body of an article is a hard or a soft paste porcelain without determining the crushing strength, and of course a mechanical test is exceedingly difficult to apply to such an irregular body as a line insulator. Even the chemist is here upon ground in which he is not sure, since the differences between the clays and the glasses are chemically so slight that the result of an analysis is of very little worth. While this is undoubtedly the greatest difficulty in the matter of insulators for withstanding high potentials and carrying lines of great weight. it is the point in which the manufacturers are deficient in their apparatus. since there is hardly a factory in the country which is equipped for pressing the heavy high-voltage line insulator more solidly than articles much smaller are necessarily pressed and in consequence it is probable that at the present time most of the manufacturers make an insulator which is either porous in a heavy body of the insulator head or that a much softer paste is dealt with than is used for smaller articles.

Should a manufacturer attempt to mix and press a hard-paste clay which shall give a thoroughly solid line insulator of the greatest size, he would also encounter the difficulty that clay when pressed is not a liquid body. and in consequence pressure applied in one direction is likely to produce cleavage lines in the insulator, and in consequence we may not at the present time say that insulators of the form now used can be made solid from dry hard-pressed clay without danger of the production of such cleavage lines, and in consequence we must use a softer paste until the proper form of insulator shall be developed, or perfect the molding of the hardest paste used in the driest possible state and sufficiently hard pressed for complete solidity after baking. These cleavage lines are especially apt to occur where irregularities in pressure are sustained by the mass of clay in molding. That such irregularities must almost inevitably occur will be evident to one who examines carefully any insulator with long thin petticoats; and furthermore, this same examination will point to a danger of the petticoat splitting away from the head of the insulator in baking, when, as has been said, the shrinkage of one-eighth occurs. The effect of this shrinkage is well known to ironmolders, and no competent patternmaker would attempt to join long thin plates to a heavy body without in some way taking care of their tendency to split away from each other when shrinkage occurs. In consequence, the most successful designers of articles for manufacture in pressed porcelain are those who have had thorough training in molding complicated cast-iron shapes. Whether the petticoats are broken away from the mass of the insulator in pressing or in shrinking when they are baked, we find that most of the failures of such insulators when pierced by high voltages occur along cracks which are found in the porcelain at about the point where the petticoat is joined to the heavy head.

Coming from the kiln, articles made of hard-pressed porcelain, however smoothly molded and however solid in the interior, are found to have a surface which is dull and somewhat rough, and where a smooth shiny surface is desired, glaze must be applied. Glaze is a glass applied to the exterior surface of the baked porcelain and fused on by subsequent baking. The glaze is perfect when it flows evenly over the surface of the article, and when it does not crack on coming from the kiln, or subsequently when exposed to varying temperatures. Cracking of the glaze is technically termed "crazing," and crazing is due entirely to a difference in the coefficient of expansion between that of the glaze and that of the underlying porcelain biscuit. It would seem at once to be the most reasonable proceeding to glaze our porcelain biscuit with the material of its body; but if this body is that of a hard-paste porcelain it is not sufficiently fusible for use as a glaze, and in consequence the surface must be covered with something more fusible. Accordingly, the selection of a glaze which shall have the same coefficient of expansion as that of the porcelain body is a matter of the greatest difficulty. This difficulty increases as the thickness of the glaze is increased, on account of the fact that while a thin glaze may have sufficient elasticity to give with movements of the underlying porcelain, a heavier body of glaze will not yield so readily.

That this should be true is apparent at once by the examination of a glass thread, which can be bent and even woven, while the glass rod from which it is made seems to be almost absolutely rigid. Tiles have been made with a glass face as much as one-sixteenth of an inch in thickness, but this was accomplished only after a long series of experiments, with repeated failures, and only on the surface of a rough tile made of porous fire brick. The natural hard-paste porcelain of the Chinese is supposed to be glazed with pure feldspar, but a more readily fusible glass is required by almost all the European and American porcelains, while for each porcelain body a different glass is required; and not only is there probably but one glass which will glaze a particular porcelain, but also that porcelain manufacturer is to be congratulated for the care and success of his research after he has found a glaze which under no circumstances of changing temperatures will craze. Josiah Wedgewood spent many years of his life in ascertaining this fact and in determining the proper glazes for his different wares, while in this country thousands of dollars have been consumed by the different porcelain manufacturers in finding satisfactory glazes. In many cases such glazes have not yet been found, and in consequence but very few of our porcelain manufacturers can make a satisfactory line insulator without a crazed surface. That we should require a surface which does not craze is due to the fact that although we do not depend upon the glaze itself as an insulation, we do depend upon it for preventing the retention of moisture upon the surface of the insulator. The nonhydroscopic character of porcelain as compared with glass therefore depends upon the character of the glazing surface and also upon its mechanical perfection. There is here a danger in the use of some porcelains, that while when made the smooth glaze is nonhydroscopic, the glass necessary to use for glazing will be soluble, and when weathered will present a rough surface, even though no crazing should ever occur. Indeed, it is probable that all porecelain glazes will ultimately weather, since the hardest glass we know of is that made of pure feldspar, which, even a slight study of geology tells us, is destroyed by atmospheric influences, and this is an additional reason for turning our attention from the glaze to the porcelain body when we speak of insulation resistances; and even were this weathering of the glaze removed to a remote possibility, we do know that any glaze will be worn away from the insulator by the contact of the line wire which the insulator is destined to support.

Having now examined carefully the necessary details in the manufacture of porcelain for insulators, we are prepared to give some guide for the writing of proper specifications and the pointing out of tests which should be made upon a porcelain insulator in order to obtain the best product that our manufacturers can at the present time produce. It is useless for the engineer to attempt to limit the porcelain manufacturer to certain pastes or glazes, since the clays used by different makers, though bearing the same names in different parts of the world, are not at all the same inultimate character—one or two per cent difference in the amount of water contained by the kaolin changing the whole character of the mixture necessary in the production of hard porcelain. And, as we have said, a different glaze is required for each mixture of clay, therefore these details must be left entirely to the manufacturer himself, since he is better able to make the choice necessary for a successful product than any engineer, no matter how carefully the latter has studied the use of insulators and the manufacture of porcelain. But, at the same time, the user should endeavor to ascertain which manufacturer uses the strongest paste and produces the densest insulator. Strong pastes can be chosen from soft pastes by mechanical tests alone, and the ability of the insulator to withstand shocks as well as pressure should be carefully tested.

In applying electrical tests it seems foolish to attempt only tests upon the finished glazed articles, since if the glaze is perfect it will completely mask the most serious extent of porosity, and even twice the potential of the line may not pierce a defective insulator, which will fail during the first rainstorm after the glaze has been worn away by the wire. The proper time, therefore, to apply any electrical test to the porcelain insulator is while the insulator is in the biscuit and before it has been glazed. It is always perfectly easy to test for porosity and to stamp the accepted insulators under the glaze by a mark which cannot be counterfeited after glazing has been performed. Even a galvanometer test at moderate potentials in this stage will furnish more accurate knowledge of the state of the porcelain than a high potential test after the glazing has been applied. Especially is inspection at this time important, as the glaze will mask cracks as well as porosity, which cracks would be apparent to the eye of the inspector before glazing, although completely covered by skillful work in the glazing process. The final inspection of the finished insulator should turn upon the perfection of the glazed surface, although it is foolish to attempt to obtain an insulator glazed in every part, since the insulator must be carefully supported in the glazing furnace, and where it is supported the surface will remain rough. It is indeed possible to specify the position upon the insulator of this rough surface, but one cannot expect to obtain a piece of porcelain covered with glaze in every part.

Finally, it should be pointed out that the relative position of the wire and the petticoats demand some study, since if the petticoats are likely to be cracked away from the body of the insulator at their point of attachment with the head, it seems wise to remove the wire from this danger point as far as possible, although, of course, actual contact of the wire with a crack is not necessary for piercing through that crack, since the high potentials now used will leap along the surface of an insulator from three to five inches, and, in consequence, if the path from wire to pin through a crack is less than the sparking distance of the potential used, leaks will occur through a crack even though neither pin nor wire be in contact with it.

It certainly seems, therefore, that, although we may improve our present insulators by a careful study of their material and form, it is at present unnecessary to attempt any redesigning of the insulators in use until we have thoroughly tested the capabilities of our porcelain manufacturers to produce insulators of the present form which shall be sufficiently strong to carry the wire and sufficiently solid to prevent the escape of electricity through the body of the porcelain without reference to the character or existence of glazing.

Illumination

THE GAIN IN USING LATEST TRANSFORMERS.

THE economic results obtained by the substitution of old type transformers by those of most recent and improved manufacture, and by the use of one large transformer for several small ones, have been demonstrated very clearly and convincingly in a compilation of reports received from certain electric lighting companies which have made the change. In almost every case the change has resulted not alone in a far more perfect operation of the system, perhaps a minor consideration, but in an actual concrete, tangible saving in dollars and cents.

Improvement in transformer construction and the use of larger units follow naturally after similar developments already completed in the machinery of many of the large central stations of our country. The replacement of a large number of transformers of small capacity, manufactured when the art of transformer construction was not so well known as it is to-day, by a few improved transformers of large capacity has produced, and is producing, results startling in their importance. The figures shown in the compilation are interesting and should compel the attention of the manager of every station supplying current through transformers.

The first instance is that of a company operating in a town of 56,000 population in Massachusetts. In this case 57 small transformers built in previous years were supplanted by 18 of one of the latest types. The total light capacity of the superseded apparatus was 1499 lights, of the newly installed transformers, 1624. The total core loss of the old transformers was 5866 watts; of the new, only 1348. So much for the electrical facts. The saving in dollars and cents is calculated as follows: 39,578 kilowatt hours are saved yearly by the change. The value of the saved energy may be estimated at $527.70—equivalent to a saving per light capacity per year of 36.2 cents. Neglecting all the advantages of the change, except those accruing from the decreased core loss, the expense will be met in one year and nine months.

The light capacity of the plant is increased 9 per cent, the core loss decreased 77.5 per cent. Furthermore, on account of the decreased core loss, not less than 4518 watts are available for sale at the regular rate with the present station apparatus. This enables the company to add ninety lamps to its circuits, producing an additional income of about $675.00.

The second instance is in another Massachusetts town. Here 40 new type transformers supplanted 53 old ones. The total light capacity of those returned was 1135 lights, of the new, 1070. The core loss in the old type transformers was 4845 watts, of the new type, 1343 watts. In this case the annual saving is 30,678 kilowatt hours, or about $409.00; and corresponds to a saving per light per year of 35.2 cents. The expense of the change, counting core loss alone, will be covered in two years and nine months. 3502 additional watts are available for sale, increasing the income to $525.00 per year, while by the use of lamps of a higher economy, some 535 kilowatt hours additional are also available for sale.

There are still three more striking cases, in Massachusetts, of benefits derived from a similar change. In the first, the regulation of the station had been so poor that the lamp bills had increased to such an extent that the question demanded immediate attention. While the saving was comparatively small, the beneficial results brought about by the change have proved highly satisfactory. In the second, 81 small transformers of old type were replaced by 3 of a new type. The core loss of the returned transformers amounted to 2568 watts, of the new ones, 280 watts. The resultant saving per annum is 20,043 kilowatt hours, or $267.00, the saving per light capacity per year, 25.74 cents. This is an all day station and it is calculated that only eight and a half months will be required to wipe out the investment. The third case involves the supersession of 193 old type transformers by 37 new ones, the total light capacity of the former being 6035 lights, and of the latter, 3210 lights. The total annual saving is 51,203 kilowatt hours, or $683.00. and the total saving per light capacity, 14.68 cents. In five years and two months the cost of the change will be fully covered. The capactiy of the plant has been increased 36 per cent, the energy required to operate it decreased 47.1 per cent. 5843 additional watts were made available and thus an additional capacity of about 116 lights was obtained without adding to the station apparatus. If these lights were burned but three hours daily the result would be an additional annual income of $960.00. On account of the improved regulation entailed by the change, high efficiency lamps can be used and about 410 more watts saved. This adds $109.46 to the total annual saving.

Several interesting changes have also been made in the West. One instance in particular merits attention. The details of the change are not available, but by centralizing the transformer distribution, the rate of switchboard income was changed from 4 cents to 12 cents per kilowatt. Another Western plant reports that its 1140 volt circuit equipped with old style transformers showed 6 to 7 amperes in the day time, while with the new transformers only a fraction of an ampere is shown.

Facts such as these tend to prove not only that constant improvement is taking place in electrical apparatus, but that station managers are realizing that, to secure the most economical results on their systems, such improved apparatus must replace older types built when electrical knowledge had not reached its present high standard. A saving here, less trouble there, the extinction of a difficulty at another point, result in a general benefit which can be exactly calculated in dollars and cents, and thus tends to the general well being of the progressive station and communities in which the newer methods are adopted.

Personal

Mr. A. P. Brayton, President of the Pelton Water Wheel Company, has returned from the Hawaiian Islands, where he found full restoration to health.

Mr. M. E. Baird, general manager of the Eddy Electric Manufacturing Company, of Windsor, Conn., is making his annual tour throughout the West.

Mr. John West Thompson, Installing Engineer for the Mexican General Electric Company, with headquarters at the City of Mexico, and who is of the Stanford '95 class in electrical engineering, is in San Francisco.

Mr. H. C. Wybro has retired from the firm of Wybro & Lawrence, of Los Angeles and San Francisco, and has accepted the Pacific Coast agency of the Walker Company, of Cleveland, Ohio,, with offices at 53 Chronicle Building, San Francisco.

Mr. T. H. Macdonald, for many years chief engineer of the various steam stations now operated by the San Francisco Gas & Electric Company, resigned therefrom on December 31st last, to accept the chief engineership of the Hawaiian Commercial Company's steam plants on the island of Mauii, H. I. The high esteem in which Mr. Macdonald was held by his fellow workers found fitting expression on the eve of his departure, in a massive gold watch chain, with suitably inscribed diamond locket.

Mr. A. E. Brooke Ridley has returned to San Francisco from a two months' trip East and abroad. While in London he gave special attention to a study of the details of garbage cremation and to the utilization of heat therefrom for the operation of electric plants. Mr. Ridley was also successful in personally securing the Pacific Coast agency for the Electric Storage Battery Company, of Philadelphia, manufacturers of the Chloride Battery. This agency has heretofore been held by the Union Iron Works, although under Mr. Ridley's management.

Dr. N. S. Keith, so well and favorably known in electrical circles of the West, is a welcome visitor to San Francisco and will probably remain here for a month or two. Dr. Keith has been absent since 1893, when he went to Chicago to attend the World's Congress of Electricians, afterward continuing on to England, where he has remained most of the time since. His principal association was with the Sandcroft Engineering Works, near Chester, England, where constant current, high potential machines were built under the Keith patents for ininstallation in many portions of Europe and Africa. Not the least of the distinctions due Dr. Keith is the fact that he is the founder of the American Institute of Electrical Engineers.

Fraternal

THE TRANSMISSION ASSOCIATION.

The third quarterly meeting of the Pacific Coast Electric Transmission Association is to be held at the rooms of the Association, 175-178 Crocker Building, San Francisco, beginning Tuesday, February 15th, next, at 2 o'clock, and to continue thereafter until the business in hand shall have been disposed of.

The principal topics for papers and discussion will be "High and Low Potential Switchboards," "Electric Hoists," and "Character of Motor Loads." These themes and the interest which is being taken in preparation for their consideration, vouchsafe a most interesting and profitable convention.

It is probable that the committee on By Laws and Constitution will render its report and that the organization of the Association will be permanantly effected.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

A SERVICEABLE LAMP GUARD.

The incandescent lamp has worked its way into many uses that would not be possible were it not for the attachment known as the lamp guard, and a strictly first-class guard that may always be relied upon and which can be bought for a reasonable price, has long been "conspicuous by its absence," so to speak, from the electrical market. Now, however, there is little if any room for improvement either in price or quality of this most useful device, since the "Acme" wire guard for incandescent lamps has been placed on the market by Messrs. P. R. Wagor & Co., 275-79 Main St., Springfield, Mass.

The Acme lamp guard is simple, durable and easy to attach or detach, if desired, and it has gone into very general use even in the short time since it was introduced. The firm has very good reports from its customers and users, and finds that its guard business has already grown into almost phenomenal proportions.

Messrs. P. R. Wagor & Company will be glad to receive and answer inquiries concerning the Acme guard from all who are interested.

ORGAN BLOWING BY A ROTARY FAN.

The first electric organ pumping installation in San Francisco has just been placed in the Trinity Church.

The wind supply of the Trinity organ presented many difficulties on account of the impossibility of adopting either of the usual methods of mechanical blowing. The main bellows, which is situated in the basement of the Church, was constructed by Messrs. Hook and Hastings with the intention of pumping by hydraulic motor; but about the time the organ was shipped from Boston, it was discovered that no satisfactory arrangements could be made for a supply of water. An electric motor was suggested, but such machines usually work on a direct current, and this cannot be obtained in the neighborhood of Trinity Church. After consultation with the California Electrical Works, it was decided to try a new style Wagner electric motor of 2-horse power, working on an alternating current, such as already supplies the lighting of the Church.

The drawback to this form of motor is the impossibility of controlling or regulating the speed, which should, of, course, vary according to the quantity of the wind required to supply the organ. After several unsuccessful experiments one of the engineers of the California Electrical Works suggested dispensing with the usual method of pumping, and proposed to deliver the air to the bellows by a rotary fan. This novel expedient proved to be a complete success, and the wind is now supplied by a No. 4 Sturtevant blower, operated by the Wagner electric motor. It is likely that Trinity organ is the only one in the world blown in this manner, but the advantages of the new method are so great that in all probability it will come into general use. The wind is absolutely steady, and the rotary blower will supply more wind to the bellows than the usual feeders.

A NEW ELECTRIC SUPPLY HOUSE.

The latest organization to enter the electrical field in the West is the Pacific Coast Electric Company, of 241 Powell street, San Francisco, which has started in business with a number of important agencies, among which are those of the Okonite Company, Ltd., the Weston Electrical Instrument Company, the Central Electric Company of Chicago, the Fuller & Curtis Company and the Scheefer transformers. The principal members of the concern are T. M. Crane, formerly of the Edison Light & Power Company, President and Manager, J. J. Gottlob, vice president, and James Maloney, secretary.

The new company has well appointed offices, an unusually well selected stock, and, besides, possesses the essential attributes of long experience and personal popularity that are so vital to permanent success.

TABLE OF CONTENTS.

Illustrated articles are indicated by an asterisk (*)

*Some Transmission Practices—

Part I.—Synchronizing Two-Phasers.. 70
Part II.—An Historic Transmission.. 71
Part III.—Changing Insulators on Live Wires.... 73
Part IV.—A Prony Brake Experiment........... 74
Part V.—A Novel Lightning Arrester 75
Part VI.—A Multi-Glaze Insulator.. 76

Transmission

An Answer to Mr. Sutcliffe's Inquiries, by Alexander Jay Wurts... 77
Acetylene and Transmission Interests.... 77
The Transmission Association.... 88

Transportation

The Mountain Railways of Switzerland, by A. Van der Naillen...... 78
*Supplanting Steam With Electric Traction.......... 78

Editorial

The Tendencies of Electrical Progress.... 80
The First Central Station.... 81

Passing Comment

Reminiscences of Early English Stations............. 82

Miscellany

The Making of Porcelain Insulators, by F. A. C. Perrine, D. Sc..... 84

Illumination

The Gain in Using Latest Transformers.............. 86

Personal

Personal.. 87

Industrial

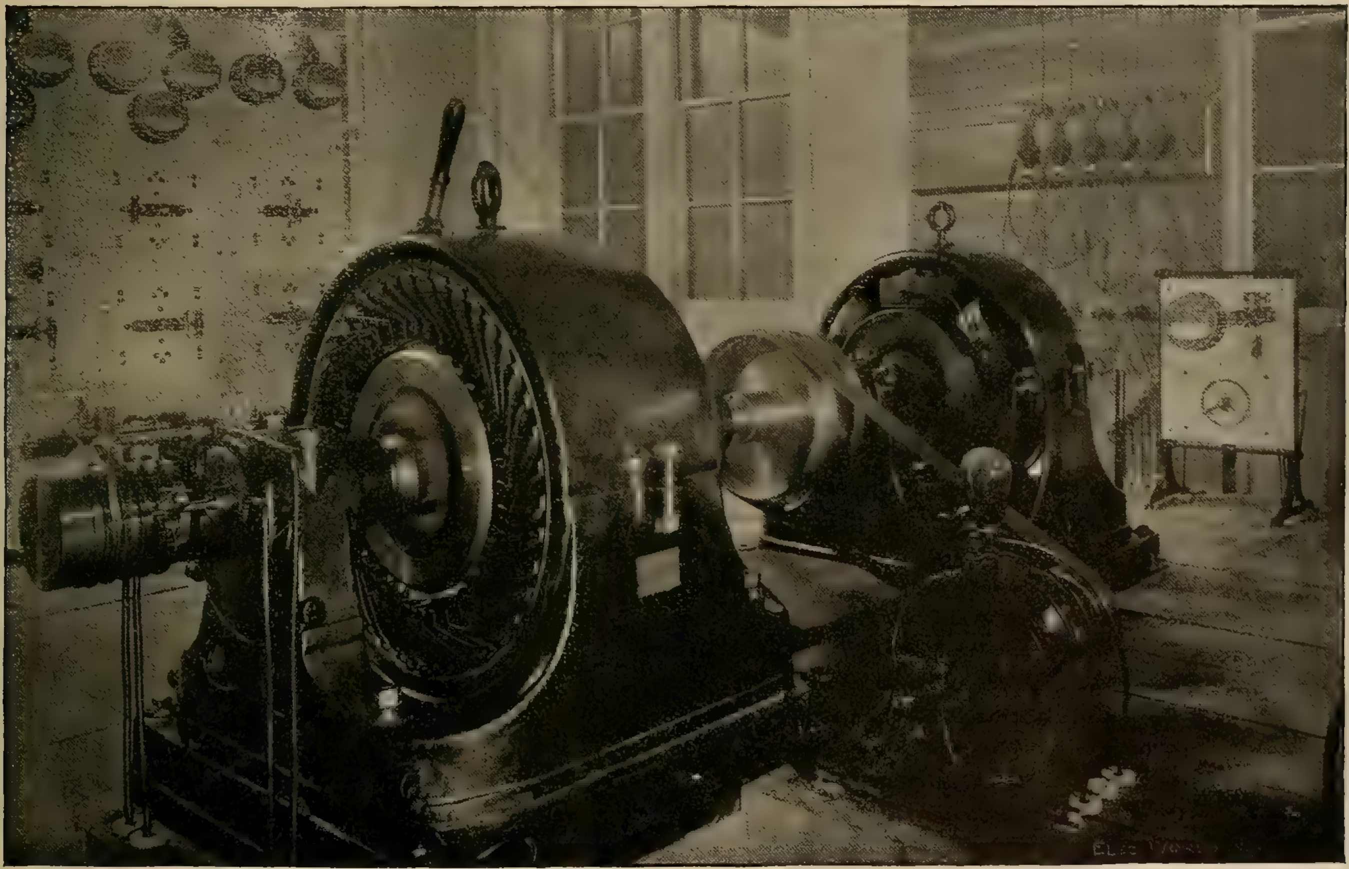
*A Serviceable Lamp Guard.. 88
Organ Blowing by a Rotary Fan..................... 88
A New Electric Supply House.... 88

The Journal of Electricity

Vol. V. FEBRUARY, 1898. No. 5

The Newcastle-Sacramento Transmission

ON the Sierra Nevada Divide southeast of Sacramento, Cal., the South Yuba Water Company owns and operates an enormous irrigating system, with nineteen storage basins, over 400 miles of canals, thirteen distributing reservoirs, and a network of canals, flumes, tunnels, pipe lines and lakes, covering two counties. At various points on the canal system are "drops," or sudden falls. The most important "drop" is one of 464 feet, of which 452 feet is utilized for the driving of the power plant of the Central California Electric Company, a corporation closely allied to the South Yuba Water Company. This constitutes the Newcastle-Sacramento transmission plant, which in many respects is one of the most interesting installations in the West, and while it has been described in a recent number of the "Electrical World" (Vol. XXX, No. 25), there are a number of interesting features concerning the plant that have not been published heretofore.


Direct Connected Synchronous Motor and Westinghouse Arc Machine at Sacramento

The water is carried from a reservoir to the power house, a distance of 6400 feet, in a 24-inch pipe of riveted sheet steel. The pipe is buried about two feet underground and its thickness increases as it approaches the power house from No. 12 to No. 6, B. W. G. At the power house the pipe forks, in a heavy cast-iron Y, into two 15-inch pipes of No. 6 steel, running to the Ys on the Pelton water wheels.

These wheels are a special design of the double pattern, two 48-inch wheels being direct coupled to each of the two 400 k. w. generators. The wheel buckets are of the Dodd pattern, with nozzles arranged to be deflected by means of hand levers located near the switchboard. No automatic water wheel governors are used, the regulation being effected manually by the switchboard attendant. This does not require very close attention, as the plant runs under a load so evenly laid on or taken off that every change can be anticipated, and even a waste of water avoided. The tail races are of substantial construction, and have heavy granite slabs at the bottoms. The power house foundations are about six feet deep, and of concrete and granite, the building itself being 80 feet by 30 feet, and its sides and roof are constructed of corrugated iron on a wooden framework.

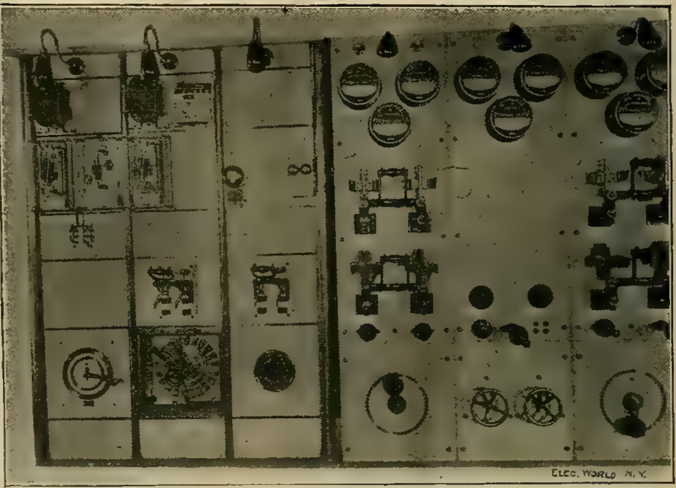
ONE OF THE GENERATOR AND WATER WHEEL UNITS

The entire equipment is of Westinghouse manufacture and the two 400 k. w. generators used are of the inwardly projecting field and revolving armature type, running at a speed of 400 r. p. m. They generate two-phase alternating current of 7200 alternations per minute, at 500 volts. The armature is not wound with wire, but with copper straps of the form and dimensions best suited to the armature slots. Each coil consists of a single turn of this copper strap, which is thoroughly insulated before it is placed in the armature grooves. After the coil is in position, strips of fibre are placed in each slot just over the bar and held in place by fitting into small grooves in the sides of the slots. Ventilation of the armature is effected by a number of radial openings between the laminations, from the open spider to the surface. The machines are excited by two 15 k. w. 125-volt exciters, driven by separate wheels, each exciter having ample capacity for exciting both of the generators.

No difficulty is experienced in running these exciters separately from the main pipe line, by a frequently suggested liability of the small nozzles being stopped up by sticks and nuts which may come down in the main pipe. To avoid this difficulty the exciter pipe is tapped into the top of the main pipe above the main gates and Y. The flow of water in this small pipe is so slow in comparison with the flow in the large pipe, that any solid matter is immediately carried through with the main stream. The exciters can be exchanged and one put in place of the other without the slightest variation in the lights, and they can be exchanged, in case of accident to either, in less than twenty seconds. This is a marked advantage over the system of belting the exciters from the main wheel, as the starting of a main wheel and generator must necessarily occupy more time than the simple exchange of exciters.

The wires from the machines lead directly to the main switchboard, which consists of three panels, one for each generator and one for the exciters. Each panel is provided with two double-pole carbon-break switches, an ammeter in each phase, a voltmeter on one phase, plug switches for the field circuit, and a rheostat. On one of the generator panels there are two lamps, which are used in synchronizing the machines, details of which process will shortly be given. The middle panel contains the rheostats, switches, ammeters and volt-meters for the exciters.

At one end of the board on a swinging arm is a voltmeter, connected with a compensator mounted on the back of the board. This voltmeter indicates the pressure on one of the phases, and the compensator introduces a drop corresponding to that in the main transmission circuit, so that the instrument indicates the pressure at the sub-station in Sacramento. When there is a light load and a small drop the compensated voltmeter and the voltmeter on the generator panel will read practically the same, but when there is a full load the e. m. f. on the generator must be increased until the compensated voltmeter gives the proper indication. The difference between the indications of the voltmeter connected to the bus bars and that on the compensator obviously gives the drop in the line.



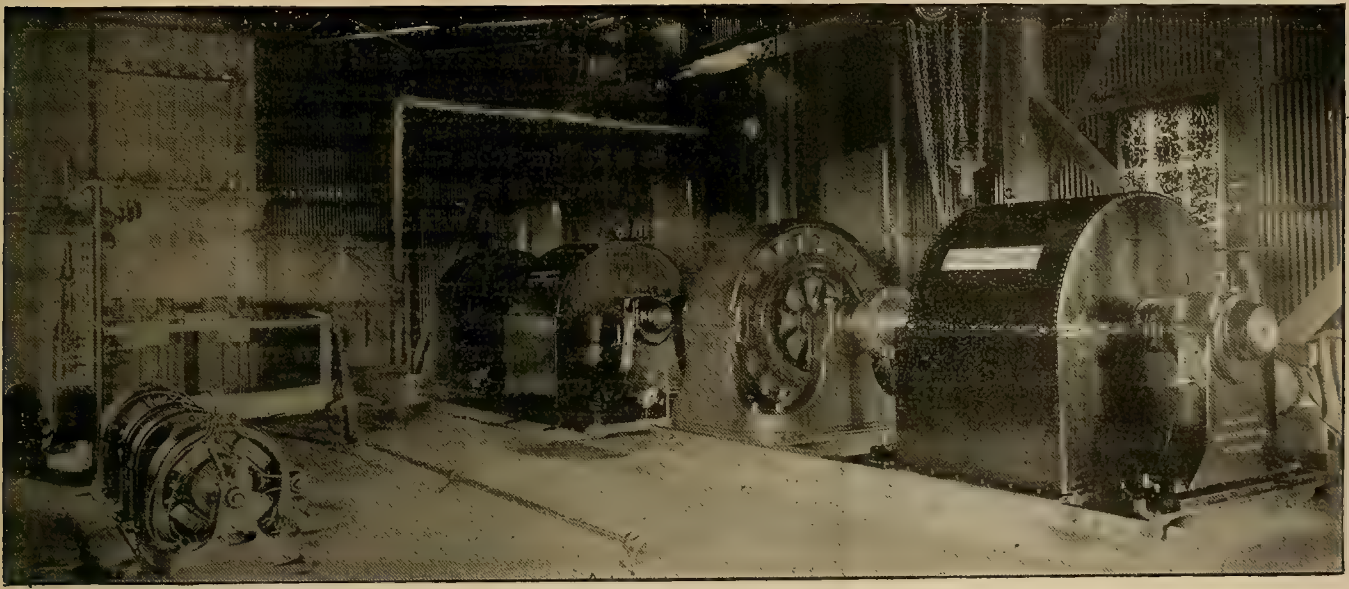
THE STATION SWITCHBOARD AT NEWCASTLE

Each generator is connected directly through the switches on the switchboard and fuses to the primary of the step up transformers which are connected to transform from two phase to three phase and deliver current at nearly 16,000 volts to the transmission line. Four step-up transformers, each of 150 kilowatts, are connected on the Scott system in two pairs of two transformers each for the two-phase-three-phase transformation. The terminals from each set of transformers are connected through fuses directly to the transmission line.

The rather surprising fact that only 600 k. w. in transformers are used while 800 k. w. in generators are installed, is explained as follows: The water plant was intended for 600 kw., but when the machines were under consideration, Dr. Van Norden decided that it would be better to have either of them large enough to carry the whole load for a short time, in case of emergency; therefore rather than install two 300 kw. generators, it was decided to install two 400 kw. machines, having a large over-load capacity, and as the 600 kw. load only continues for a few hours in the evening, one generator usually carries the whole load during twenty-one hours of the day. The transformers are worked in parallel on both sides and one geneator therefore sends current to the whole 600 kw. in transformers.

Both step-up and step-down transformers are oil insulated. The coils of the transformers stand in vertical planes and are spread apart to allow a free circulation of the oil between the coils, thus securing a high insulation and enabling the oil to come in close contact with various parts of the winding and convey the heat to the case by convection. Ample provision is made for cooling by air circulation without the use of water jackets or fans, but by the simple provision of vertical air tubes through the walls of which the heat is transmitted from the oil to the air.

In starting the plant some rather interesting features in regard to the synchronizing of polyphase dynamos were shown. The two generators were brought up to the same speed and voltage and after carefully synchronizing them, they were thrown together, no current flowing through the ammeters. In order to assure the electricians about the plant that there was no difficulty in synchronizing the machines, the following experiments were then made. One machine was excited to a potential of 400 volts and the other to a potential of 200 volts, and after synchronizing them, they were thrown together, the resulting potential being 300 volts, with a small current flowing through the ammeters. The field current was then entirely removed from the lower voltage machine, and the two generators still continued in synchronism. The water was then thrown off of the wheel operating the generator without field, and it continued in synchronism with a somewhat increased current flowing in the ammeters. The field current was then again applied to the machine without water and the field current was taken off of the machine whose wheel was being operated by the water, when the two machines continued in synchronism, the one without water having the field current, the one with water having no field current. Under these last two circumstances a considerable current flowed through the ammeters, but the machines continued in operation and synchronism as silently as though nothing had occurred. Under the last conditions with a full field charge on the machine having no water applied to its wheel, and no field current on the machine having water applied to its wheel, the resulting voltage was about one-half of the full voltage.



Interior of the Power House of the Central California Electric Company

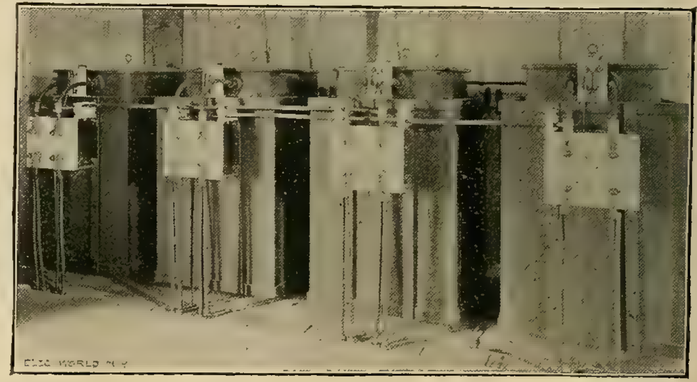
The pole line is substantial and well constructed. For five miles, redwood poles 30 feet long, 10 inches square at the butt, and 6 inches square at the top, are planted 5 feet in the ground. For the remaining twenty-three miles the poles are 40 feet long, of Washington cedar, and planted five and one-half feet deep. The distance between the poles is 125 feet. The cross arms are five feet long, with two pins and two insulators. One set of insulators is secured to the peaks of the poles, on iron Ys, but it is stated that these ridge irons would probably be replaced by wooden pins set in the top of the pole in future installations of this kind. There is a light arm also attached to the poles for telephone wires. The three wires of the main circuit are No. 4, B. & S. bare copper, secured one to the insulators on the peaks of the poles and the others to those on the top cross arm. The wires are thus placed in positions corresponding to the three corners of equilateral triangles and the inductive drop is rendered as harmless as possible. The lines are, however transposed or "barreled" at the end of every mile of wire, which was done in the interest of the telephone circuits placed on the poles below the transmission line cross arms.

A Method of High Tension Wiring

The second cross arm carries the wires for local service in Placer County. The insulators were manufactured by Fred. M. Locke, of Victor, N. Y., and are triple petticoat porcelain and made to carry a current of very high potential without cracking or puncturing. They are secured to the cross arms by steel pins, thus providing a solid support for the wires. General Manager Van Norden states that these insulators have proved very satisfactory for the transmission of 16,000 volts. The line worked perfectly when the plant was first put in operation, and only a few of the 6000 insulators have developed any weakness since they were put in service. Some of these appear to have been broken by malicious shooting or other non-electrical causes. When these accidents occurred the poles were set on fire by the current, which, however, did not interrupt the service, as the pole burned away, leaving the wires hanging free. On one occasion two poles nearly a mile apart were found to have been burned, owing to faulty insulation, which allowed the current to leak from one wire through one of the poles to the ground, and back through the other pole to another wire of the circuit. Both of these poles were badly burned, but neither the attendant at the generating station nor the attendant at the sub-station knew that anything unusual had happened.*

Each end of the transmission line is protected by Wurts non-arcing metal lightning arresters. There are six choke coils connected in series in each of the three wires and from the line at the junction with the coils, there are spark gap paths to the ground, through which lightning discharges can pass. No resistances are introduced in the ground circuits, so the lightning discharge encounters nothing except the spark gaps on its way to the earth.† At the sub-station at Sacramento the current is received on a high tension switchboard panel, by which it may be delivered to either or both of two sets of step-down transformers.

Special precautions were taken in the design of the fuses and switches for use on this high tension circuit to secure safety, as well as reliability and simplicity. The fuse terminals are enclosed in hard rubber fittings, which are supported on high tension triple petticoat insulators. The fuse is of fine wire, a foot or more in length, enclosed in a rubber tube and the contact between the fuse and the terminals is made by a screw which is entirely covered by a hard rubber cap. The high tension switchboard consists of a marble panel, with receptacles at the middle for the line terminals, and at the top and bottom for the terminals of the circuits to the step-down transformers. Connection between receptacles is made by plugs connected by flexible cable. The receptacles are entirely enclosed in hard rubber, so that there are no contacts exposed at any time, the plugs and the cables joining them being thoroughly insulated. Detachable wooden handles are used for handling the plugs when they are to be inserted or withdrawn on a live circuit, and an insulated floor or platform is arranged, on which the attendant stands when making connections on this switchboard. To prevent accident in case of a breakdown in insulation, or dampness on the surface of the



The Raising Transformers at Newcastle

---

* For additional details see Van Norden on "The Line Insulation of 16,000 Volts" in the Journal of Electricity for September, 1897, Vol. IV, No. 6, page 113.

† See Sutcliffe on "Lightning and Long Transmission," Vol. V, No. 2' page 40, and Wurts on "Sutcliffe's Queries," Vol. V, No. 4, page 76.

plugs and handle, a special device is used to effectually protect the attendant from the current. Near the middle of the handle there is fastened a chain, which is connected with the ground, or the support of the floor on which the attendant stands. The latter is therefore thoroughly protected, as the escaping current has two paths between the terminals of the chain, one through the low resistance metal chain, and the other through the wooden handles, the operator, and the platform, the resistance of the latter compared with that of the chain being so great that the attendant is effectually protected. No difficulty was experienced in pulling out the plugs when the secondary of the six 75 kw. transformers was short circuited. The short circuit, which was between the transformers and the low tension fuses, was of such a nature that the high tension fuses did not blow, which it is claimed, illustrates conclusively the effectual nature of this method of breaking high tension currents.

In the sub-station there are two sets, each consisting of three pairs of 75 kw. step-down transformers, which receive three-phase current and deliver two-phase current at 2200 to 2400 volts to the bus-bars of a distributing switchboard. This switchboard is provided with throw-over switches, by which either current may be thrown on either phase desired; and with fuses enclosed in lignum-vitae holders, as well as containing ammeters and voltmeters. The 2000-volt distribution is similar to that from ordinary 2000-volt dynamos. The circuits are supplied with standard transformers for reducing the current from 2000 volts to 100 to 200 volts, as may be desired. Transformers are used for ordinary lighting work, and for the supply of two-phase motors, and also by simple combinations for the supply of three-phase motors.

In the sub-station are two 50 hp. induction motors, direct coupled to 60 light, Westinghouse separately excited, direct current, 9.6 amperes, series machines for supplying arc lights. These induction motors are supplied by two 75 kw. transformers, which deliver two-phase current at 2000 volts.

Special attention is called to the use of a new protective arrangement, with which the high tension transformers are all supplied, namely, the non-arcing metal spark gap protector. This protector is connected between the low tension coil and the ground, and prevents the great rise of e. m. f. between this coil and the ground, which might occur either in the case of a breakdown of the insulation between the high and low tension coils in the transformer, or which might be caused under certain conditions by static induction between the two windings.

The protector consists of a spark gap similar to that in the well-known non-arcing lightning arresters, one side of which is connected to the ground and the other side to the middle point of the low tension winding. The normal e. m. f. of the low tension coil is not sufficient to cause sparking across this gap, but in the case of undue rise of e. m. f. the current jumps across this gap and connects the coil to the ground, thus affording protection from the dangers which would arise if the low tension circuit were at a great difference of pressure from the ground.

The plant has been in regular and successful operation for over a year, during which time there have been very few shutdowns, and those for brief periods only. The plant is shut down for a few minutes every Sunday morning for a general inspection and cleaning of the apparatus and the plant attests the perfect success attending the transmission of power for a distance of nearly 30 miles, involving the use of nearly 6000 insulators on a 16,000 volt circuit.

The Central California Electric Company was organized by Mr. Warren Van Norden, President of the South Yuba Water Company. The work is in charge of General Manager Dr. Chas. Van Norden, and the electrical features of the transmission are in the charge of Mr. E. W. Sutcliffe, superintendant and electrical engineer for the Company.

Thanks are due to Mr. R. S. Masson, electrical engineer of the San Francisco office of the Westinghouse Electric & Manufacturing Company, and to the "Electrical World" for information and illustrations given.

Gas

A FRAUD UPON ELECTRICITY.

By Sidney Sprout.

HAVING been, during the past few years, the consulting engineer of several electric lighting systems that are operating gas works, I concluded, while in the East a few weeks ago, to make a personal investigation of the merits of a new gas process by which it was claimed that a good fuel and illuminating gas could be made at a remarkably low cost. It appeared to me that if I found the process to be as represented it would be to the great advantage of some of my employers to adopt it. If not, such information as I gathered would doubtless be of value to me in a professional way.

I confess it was with some misgiving that I took the matter up because of the claims made in a circular advertising the process, which stated that it was an "electric process" for manufacturing gas. This does not mean that I thought the process would be without merit, because it professed to use electricity, but the wording of the circular referred to excited my suspicion. At the beginning it stated that by this process could be made a fuel gas equal in every way to natural gas at a cost of less than 10 cents per thousand cubic feet. My experience had been that no fuel gas could be made at so low a cost. The pamphlet then went on to state "The invention . . . . . . is a pioneer in a new field, namely, the using of electric action obtained inside the generators for the purpose of breaking up the component gases which go to form a commercial fuel gas, all former processes having depended upon the action of heat to accomplish this purpose. But heat does it only partially, while electric action does it completely. The successful introduction of this powerful agent into the manufacture of gas for fuel and light, has given similar astonishing results to those obtained in so many other lines of discovery and improvement by its means." I could not believe that the component gases of a fuel gas could be completely broken up by "the using of electric action." I looked up the patent, but this added to the mystery as will be explained.

The pamphlet also stated that the Kalmazoo Heat, Light and Power Company of Kalamazoo, Michigan, was manufacturing gas for fuel and lighting purposes by this process, and so I went up to that city from Chicago where I found that the plant referred to was using what has long been known to gas engineers as gas made by the Hall Process, which is based on patent No. 494,200, issued to T. G. Hall and dated March 28, 1893.

About the middle of July, 1891, the Michigan Fuel Gas Company started a plant using the Hall process in Grand Rapids, Mich., but the company failed and the apparatus was moved to Kalamazoo, where, after necessary alterations and additions had been made, it was set up as a plant of the Kalamazoo Heat, Light and Power Company. The apparatus as erected at Kalamazoo, consists of a generator or combustion chamber into which coal and oil are injected and which is supplied with a strong blast of air. From the generator the products of combustion were led to the mixing chambers, into which steam was introduced. It is in these mixing chambers that the so-called "electric action" takes place and my particular attention was given to this detail of the apparatus. The mixing chambers contain what were termed "receptacles" of copper and iron and it was represented that these receptacles, being of "opposite electric polarities," possessed the ability to break up the component gases of fuel gas. No external source of electricity was applied to the elements or receptacles, but instead the so-called electric action was attributed to the thermo-electric powers of copper and iron under heat. From the mixing chambers the gas was carried on through the usual condensers, scrubbers and purifiers to the gas holder, the product being a form of Dowson gas which is one of the lowest forms of producer or fuel gas. I learned subsequently from a report of an engineer of the company that the gas had a specific gravity of 0.913, which makes it almost as heavy as air. This is a disadvantage in that such a heavy gas is unstable when burning, and a comparatively slight draught of air blows it out. The gas is used only with incandescent gas burners of the Welsbach type, as when it burns in an ordinary burner it gives a pale blue flame of low candle power. It is, therefore, distinctively, a fuel gas, which, however, gives satisfaction as an illuminant when burned in incandescent gas burners.

Right here I think it is but just to state the opinion that the officials of the Kalamazoo plant as well as those who are interested in promoting the process, are sincere in the belief that electricity is an indispensable factor in the process; that it is generated in material quantities in the mixing chamber, that it decomposes the component gases into a nascent state from which they reunite into a perfect gas, and that taken altogether the process is one of unusual merit. None of them are conversant with electrical theories or practices, and that their electrical reasonings are at least fallacious is not to be doubted.

The question which is of immediate interest is naturally in relation to the so-called electric action of copper and iron, which are electrically insulated from each other and are so arranged that they are exposed to the heat of a gaseous mixture consisting of steam and the products of the combustion going on in the generator. The receptacles were of a cup-shaped appearance arranged in rows along the fire bricking and in reply to my inquiries I was assured that an electric action took place between the gas and the receptacles, as such had been conclusively demonstrated by the fact that on leading wires out from the iron and copper elements to a galvanometer, the presence of electricity could be detected on the galvanometer needle, and in fact the needle could be made to swing violently. In making these experiments one of the wires leading from the galvanometer was connected to the copper pieces of several of the receptacles, while the other wire was connected to the iron parts of the receptacles, just as an electrician would couple up several cells of batteries "in parallel," or "in multiple-arc."

The movement of the galvanometer needle in this experiment was accepted as proof that the iron and copper receptacles, being of "opposite electrical polarity," excited a decomposing influence on the gases that were forced by the blower to pass through the mixing chamber in, about, and between the receptacles. I could get no further information than this as the plant was in continous operation which prevented my making a close examination of the receptacles. I saw and heard enough, however, to convince me that the electrical features of the process were spurious.

The statements made in a preceding paragraph are alone sufficient to convince any well-informed electrician of the imposition that the Hall process has practiced upon the patent office and upon the general public; but while the electrician comprehends the enormity of the imposition at a glance, the general public does not understand it all and risks its money in an enterprise which is bound to fail and, having failed, the public will certainly blame the electrical industry for it. It is in order that fraud may be exposed and in the hope that unsuspecting capital may not be sunk in spurious processes of a so-called electric nature, that I have concluded to contribute this article.

Let us have a thorough understanding of the situation as presented by the claims of the advertising pamphlet, by the specifications of the Hall patent, and by my own observations of the Kalamazoo plant. The inventor does not confine himself "to any particular receptacle, or any particular way of insulating materials of opposite polarity," but states that he has "found that the materials of opposite electric polarity may be contained in receptacles arranged in the following manner: that is, one of such materials contained in a receptacle, as a porous cup of refractory material with a second porous cup of refractory material imbedded therein, such second cup containing the material of opposite polarity." Claim 6 of the patent specifications states that "the materials of opposite electrical polarities" do not come "into electrical contact with each other." These statements show it to be the intention that the materials of opposite polarity are to be insulated from each other, that is, they are not to be in actual contact with each other, metal to metal; this is a point that should be borne in mind. I was informed in Kalamazoo that these materials were of iron and copper, and it is so stated in the specifications. From a thermo-electric standpoint, these metals are "of opposite electrical polarity" and morover, the elements, as the materials may more properly be called, are exposed to the high temperature of the mixing chamber which is, I judge, in the neighbood of 1500 degrees Fahrenheit. . . .

It is well established in electro-physics, that if two dissimilar metals are brought in contact and their junction is heated, a current of electricity will flow from one to the other, the direction and amount of current flow vaying with the metals used and with the conditions of temperature, Copper and iron are of opposite electrothermal polarity and they posssess thermo-electric propperties to a fairly well marked degree, but no electric action can take place between iron and copper or between any other dissimilar metals unless the two metals are in actual contact with each other, or in other words unless they are not insulated from each other. The Hall patent particularly states that the metals constituting the receptacles are not in electrical contact one with the other, hence if they are in a condition which the patent states, it is a physical impossibility for the copper and iron elements to generate electric action by thermo-electric or any other means. If the two metals are in electrical contact, an electrical action may take place, but in any instance the electric potential will be exceedingly minute. There is no possibility that a thermo-electric contact may be established between the elements by coatings or impregnations of carbon, and it is equally impossible for an electrical contact between the elements to be established through the surrounding gases, which are at high temperature and of almost infinitely high resistance.

Now let us see how it is possible for an indication of the presence of electricity to be given by the needle of a galvanometer, as was stated to be the case at the Kalamazoo plant. If a piece of copper wire be connected to a bar of iron and the bar be placed in a forge and heated, an electrical potential will exist between the free ends of the bar and wire, and if they be connected to a galvanometer, its needle will manifest its presence on the galvanometer, as was stated to be the case at the Kalamazoo experiment, where the electrical indications obtained on the galvanometer were sufficiently pronounced to hoodwink almost any non-electrical man into the belief that electricity was used in the process. Hardly a plant of any nature in any branch of industry can be found but that will, on a similar test, show the presence of these minute currents of electricity in one portion or another, and so sensitive are the different processes of electrical detection and measurement that even a wire stretched in the air and swung above the surface of the earth will generate enough electricity by cutting the magnetism of the earth to deflect the needle of a galvanometer. The presence of electrical indications under conditions paralleled in the receptacles used in the Hall process is a most commonplace occurrence that has long since lost the element of novelty to electricians.

One further point before concluding: The principal feature of the Kalamazoo process is claimed to be "the using of electric action obtained inside the generators for the purpose of breaking up the component gases which go to form a commercial fuel gas."

The only report that has been published on gas produced by the Hall process, and which is referred to in detail in a descriptive circular of its promoters, is that of Van Denbergh, which shows that 69.1 per cent of gas made by the Hall process consists of oxygen (0.5 per cent), hydrogen (13 per cent) and nitrogen (55.6 per cent)—this latter being inert and dead and utterly useless in any commercial gas. These three gases are free elements and cannot be decomposed or broken up in any way. The remaining component gases are carbon monoxide (8.9 per cent), carbon dioxide (6.6 per cent), marsh gas (8.8 per cent) and illuminants (6.4 per cent). Electricity has absolutely no distinctive effect whatever on gases whether they be as a free element or in chemical combination—the word distinctive being used in the sense that a current of electricity will exert no influence on gases which the agency of heat will not do. The promoters of the Hall process state furthermore that this breaking up of the component parts of the mixed gases has hitherto been accomplished by the action of heat which "does it only partially, while electric action does it completely." The mixing chamber at Kalamazoo becomes very hot, and if other processes depend upon the action of heat to break up the component gases, the Hall process depends on heat to break up the gases as well as do the other methods, and an ingenous adaptation of a most simple phenomena of thermo-electrics has afforded a subterfuge by means of which the process may be rendered more attractive to capital through the devising of a pretext under which it may be called "an electric process."

Whatever may be its merits otherwise—and in my judgment it has no particular ones—and however sincere its promoters may be, I am convinced that there is nothing electrical about the process, and that it is from an electrical standpoint, at least, a bald, rank fraud.

Pneumatics

COMPRESSED AIR AT THE GWIN MINE.*

BY E. A. RIX.

CALAVERAS county possesses not only one but both of the largest air compressors in the State of California. The first one was installed at the Utica Mine, at Angels Camp, and consists of four 18x24-in. air cylinders, placed tandem to each other and driven from a water wheel under a head of about 565 feet. This compressor furnishes air for the rock drills and pumps of the Utica Mine.

The second compressor has been recently installed at the Gwin Mine, in Calaveras county, and is an extremely interesting and economic installation of compressed air for mining purposes.

The situation of the Gwin Mine is such that it naturally suggested a power plant either electrical or compressed air. The Gwin Mine is situated in a canyon, about 5,000 feet distant from the Mokelumne river and 425 feet vertically therefrom.

The mechanical opeations at the Gwin Mine are actuated by water power from a ditch running on the hillside above the mine, at an elevation of somewhat over 400 feet. This water drives the 40-stamp mill, and the hoisting works at the new shaft, and supplies such other uses of the water as are necessary around the mine, amounting in all to about 230 inches.

The Gwin Mine shaft is a new vertical shaft, about 1450 feet deep, and it is about 100 feet distant from the old shaft, through which a veritable bonanza was taken by the early day miners.

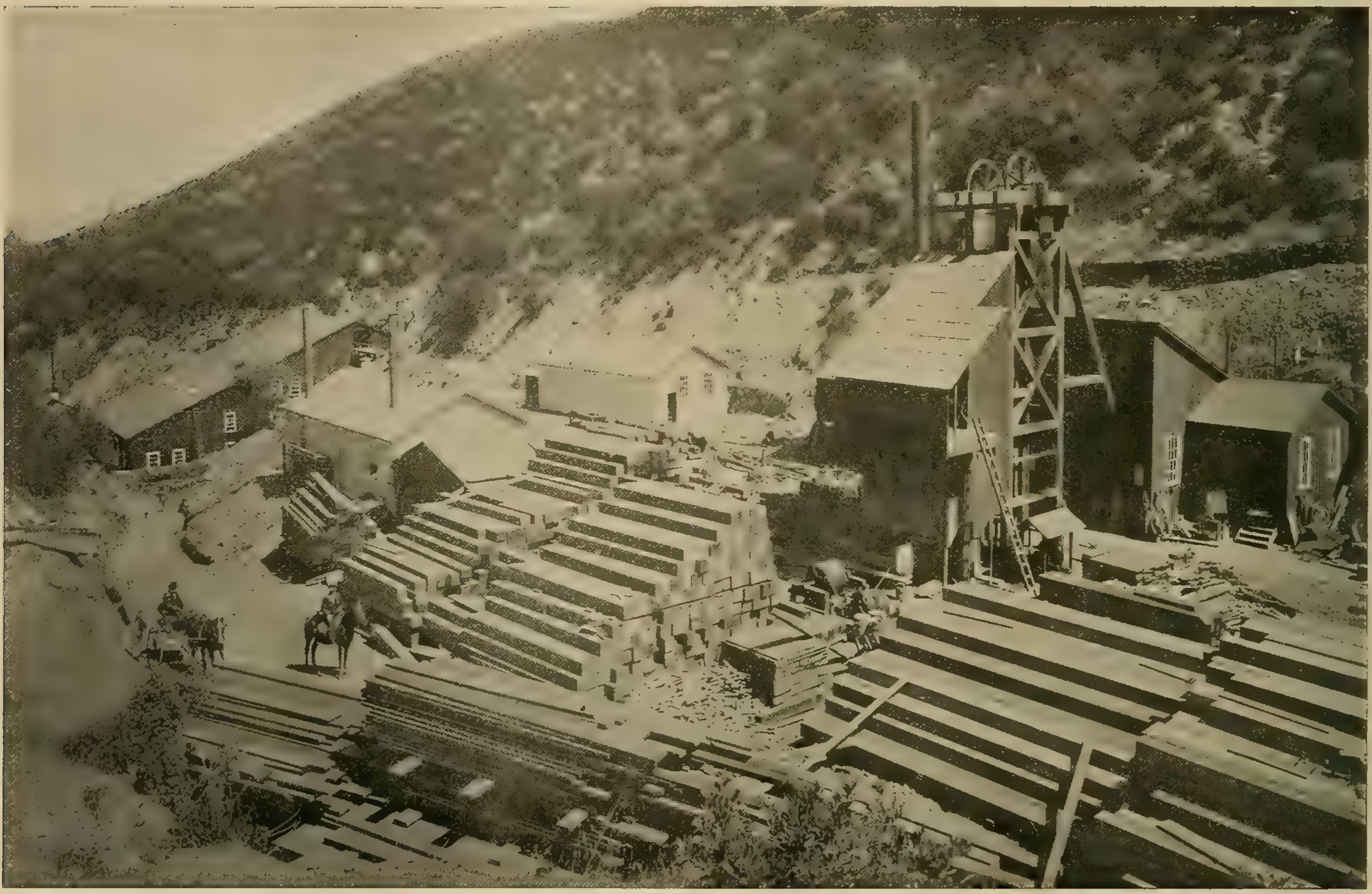
The drifts from the new shaft have approached dangerously near the old workings, and I believe in some instances the new drifts are beneath the old mine which has been full of water for the last twenty years.

The desirability of draining this mine, both for matters of safety, and to turn it into an air shaft, brought forward the problem of utilizing the tail-water running from the various workings about the mine down the canyon to the Mokelumne river. It was evident that here was a splendid opportunity to pick up a considerable amount of power with the simple cost of the investment in the plant. The 230 inches of water falling down to the Mokelumne river has a potential of not less than 230

---

*From the Golden Jubilee edition of "The Mineral Resources of Calaveras County."

h. p., just about the same amount that was used around the mine. After taking estimates and bids and considering the situation in general, the Gwin Mine Development Co. decided upon compressed air as being the most flexible power for the purpose intended, and the installation has been completed in what I believe to be a thoroughly satisfactory manner to the company. The water is first caught up from the mill and hoisting works in a large redwood tank, holding 75,000 gallons, situated just below the tail water of the mill. From this tank a 15-inch steel pipe conveys the water 4500 feet to the power-house, situated on the bank of the Mokelumne river. It is here applied under a pressure of about 181 pounds to the square inch upon a Pelton water wheel nineteen feet in diameter, making eighty revolutions per minute at its normal speed.



THE GWIN MINE HOIST.

The compressor is the same size as the Utica, viz., a Rix horizontal compressor, having four 18x24 air cylinders. The last two cylinders, however, have not been placed in position, the work at present simply requiring the use of the first two cylinders. The air is compressed to about 85 pounds to the inch and carried through 6500 feet of 6-inch steel pipe to the old shaft, following the old pipe line grade. At the old shaft the air enters two large air receivers four feet in diameter and twenty feet long each and is distributed from there down the shaft to the pumps, and to a double 10-inch hoist which was installed at the same time for the purpose of clearing out the old shaft.

The water from the old shaft stood within a few feet of the surface. A duplex sinking pump, of a capacity of 150 gallons a minute, was put to work as soon as the compressor plant started, and at the present time of writing the water has been lowered considerably below the 600 foot level, and the large compound station pump is about in position and ready to start. This compound pump will handle all the water of the 600 foot level, and the sinking pump will follow along down the shaft delivering water to the 600 foot level. At the 1200 foot level there will be another station pump from the upper station to handle the water, which accumulates below the upper station.

The pumps started on or about November 8th of last year, and have been continuously working during these past ninety days, and the ease with which the whole work has been accomplished and the small amount of power it comparatively has taken, should be good evidence that compressed air is the proper thing for this character of work.

The compressor has been making an average of from 30 to 45 revolutions, increasing gradually as the sinking pump lowered the water. At the same time the hoist has been doing the work of clearing out the shaft, lowering new timbers, men, pipes, pumps, etc. There is an ample quantity of power, generously applied, and there has not been in connection with this work the usual delays, mishaps and disappointments.

It is the intention of the mine to reheat the air in the compound pump at the 600 foot level, and also to reheat the air for the hoist, or for any other work it may be compelled to do, so as to make the matter an economical one at the time when the compressor reaches somewhere the limit of its capacity. This, however, will be some time in the future.

After the old shaft is drained and connection made with the new shaft, it will be used as an air shaft and compressed air will be used to run the main hoist of the mine, thus saving the water now being purhased for that purpose. There is an appreciable loss from one end of this system to the other, the gauges registering practically the same. There is, however, a slight difference, due principally to the difference of elevation.

The economic power is not that power which shows a high rate of economy for a two minute measurement; it is the power which costs less for a 24-hour service wherein a proper credit has been given for its utility. No power can be made to yield a high economy until it is properly used. A tangential water wheel must be speeded to 50 per cent of the spouting velocity of the water in order to give the 85 per cent efficiency claimed by the builders, and it would be as sensible to judge of the economy of this wheel when running at 25 per cent of the spouting velocity as it would to judge of the economy of compressed air where it is not used expansively. Unfortunately, utility demands the service of air at all prices and hazards, and while the results have justified the means, still a little patience and investigation might result, where the inauguration of a compressed air plant is concerned, in obtaining a plant that, over and beyond the question of utility, would be extremely economical. Perhaps it is because air, as we find it in Nature, is so abundant and free, that it suggests the carelessness with which it is used in ordinary operations, but certain it is that if more air is wanted underground, the compressor is speeded to all it will stand, but little thought is given to stopping the waste in the air being used. It is only recently that mine owners are beginning to ask about economic machines for the use of compressed air.

In the installation of a compressed air plant, the duty of the purchaser does not end in selecting a compressor which he believes to be best adapted for his purposes. His duty really begins when he commences to install it and to use the air which it supplies. There cannot be a difference of more than ten per cent between the relative economics of most of the compressors manufactured by the standard builders throughout the United States, but there can be a difference of more than this amount made in simply piping the compressor to the receivers, if it is done improperly, let alone sending the air two or three thousand feet underground.

Too much attention cannot be properly given to the installation of the plant. A little less money spent on the compressor, and a little more on the receivers would often give a better power result.

It has been considered good practice until recently, to establish with a single 10-inch compressor an air receiver 3 feet in diameter by 12 feet long, holding about 85 cubic feet, but this is far too small as a general rule, and with this compressor there should go a receiver about 4 feet in diameter by 20 feet long, holding 240 cubic feet which is about three times the former capacity. The difference between these two receivers would enable the 10-inch compressor that is limited ordinarily to driving two rock drills, to have a capacity for about three.

It is an important thing to have large conduits throughout the mine, and down the shaft, and no one-inch pipe conveying air.

A Trestle on the Compressor Line—Gwin Mine.

The difference in economy between using air cold and reheated is about 50 per cent. This tells its own story, and if by using air cold one has nearly reached his power limit, by properly reheating it can be increased to that extent.

Many suppose that reheating cannot be done underground. A very little investigation into the matter will show that there are few mines in the State, where underground reheating cannot be successfully installed. There are mines in this State reheating at 1600 feet, and at a thousand feet, and many below five hundred feet. This reheating can either be done with oil, or coke or wood, depending entirely upon the nature of the air currents in the mine. The users of compressed air for pumping in mines have been compelled to employ the direct acting steam pump, which is an extremely wasteful engine, because the compound pump would freeze up. In the present method of reheating, compound pumps can easily be employed, saving fully 50 per cent of the air used for actuating them.

The use of compressed air in mines is constantly expanded. A very interesting and novel proposition is now being demonstrated by the writer, for one of the principal mines in this State, on the subject of mine haulage. Compressed air motors will be installed on the 2,000, 1,800 and 1,600 ft. levels of the mine, to haul trains of ore cars from the face of the workings about one-half mile to the shaft, reducing the expense of hauling, from twenty-five cents per ton to five cents.

Electro-Economics

CENTRAL STATION SWITCHBOARDS.*

By F. A. C. Perrine, D. Sc.

THE switchboard in a central station should be considered not only as a means of distributing electricity, but also as a central point from which influence extends which modifies the character of the work done throughout the entire plant as well as the care devoted by the workmen to the maintenence of the station.

In every plant there is some such central point of influence, which is found in the part of the machinery to which the attention of both technical and nontechnical eyes are attracted. In manufacturing plants this central influential point is found in the engine room, and manufacturers so well recognize its influence that some years ago the cotton manufacturers of New England determined that one per cent of the capital stock of the Company expended in the equipment and proper adornment of the engine room was a profitable investment, as improving the care devoted by all the employees to the machines under their charge. The engineer and his set are the aristocrats of a manufacturing plant and if these men take pride in the appearance of their machinery all other workmen will emulate them and the general efficiency of the plant be increased.

In a lesser degree the switchboard of a central station modifies the action of the dynamo tenders as well as the linemen and lesser employees. If poor work is done in wiring the switchboard, the circuits of the dynamo room will receive little care and those outside the station will be in a worse condition, whereas no one would be willing to have a poor piece of work exposed near a carefully arranged and well wired switchboard, and the care taken in the occasional work done on station circuits will be reflected in the results obtained on the outside circuits. In consequence of this fact the appearance of the switchboard warrants an expenditure which seems almost lavish.

Extravagance is not necessary to obtain the best results at this point, as indeed extravagance is nowhere allowable in a plant, and hence by "lavish expenses" is not meant the use of marble carvings or other unnecessary decorations, but that the switchboard should be of such a character that it can most easily be handled, most readily kept in good condition, and show the best result for the pains spent in its maintenance. If this is true, the workmen are not sparing in their pains, while if extravagance is indulged and unnecessary care is required for the proper maintenance of the switchboard and if instruments are installed whose reading is not necessary for the proper manipulation of the plant, gradually an increasing disregard for the value of all instrument readings will creep in. Thus it does not pay to purchase for installation on the board every new-fangled piece of apparatus on the market, nor to foolishly decorate its surface with brass castings or marble cornices, although it does pay to use such materials that the apparatus connected with the board is not easily put out of order and that leaks through the board will be impossible. It also pays to spend an extra amount of money in making the relative appearance of the board and of the instruments such that the instruments are most readily selected and read from a reasonable distance,—therefore, in general we may say that the construction of the switchboard will be the most beautiful when it is reduced to the simplest possible terms and the materials used are those most readily kept clean when the instruments installed are the most accurate obtainable and their arrangement on the board the best for rapid and safe handling,—even when operating during periods of accidents and in the midst of possible danger.

On account of this last point, the location of the board itself is also not only not a matter of indifference, but is of supreme importance, for the proper choice of location facilitates all work about the board and extends the sphere of the good influence already spoken of. This means that a properly located switchboard is not hid in some ill-lighted corner, but is placed as prominently as possible, and especially it must be so located that it is not in the way of danger from flying belts or short circuited machines when the effects of accidents are being corrected. This has lead in many cases to placing the boards in galleries where a separate switchboard attendant is made possible by the size of the station, and as such a location makes it easily possible to insulate the floor space before and behind the board.

This matter of floor insulation is one that is often neglected, as the effect of nervous fear of the slightest shock during the time that risky changes are being made is often not appreciated by the switchboard designers. In everyday working a slight shock may not interfere with the composure of the workmen, but when handling heavily grounded circuits carrying currents at high potentials, a workman is apt to become nervous under the slightest cause for discomposure.

In general the requirements for a satisfactory switchboard have been stated and it is now necessary to consider particulars in constructions. Taking up the requirements separately and examining the commercial possibilities of fulfilling them in the best manner, we find that in the matter of material of the board itself, choice is very limited. Solid wood boards are to-day altogether discredited on account of their easy inflammability, while skeleton ones are only to be considered as meeting the needs of the smallest and cheapest plants. The material of the board, to be fire-proof and at the same time free from possibility of leaks, brings us to the consideration of only slate, marble, glass and porcelain. Lava, or other close grained stone, might indeed be available for use, were such stones to be found regularly in the market and obtainable in satisfactory quality and sizes at a reasonable price—but at the present time these conditions are not fulfilled. Slate was at one time the favorite material for the construction of switchboards, on account of the fact that no other stone is as readily drilled and worked, nor can any other stone be found which is so cheaply obtained in large flat slabs—but unfortunately slate is a material which is very variable in character, containing in some cases large amounts of partially reduced metallic oxides, which lower the specific resistance of the material so far that it may become dangerous for high potential work, and in any case slate is so porous that it is not thoroughly safe to use without the European precaution of thorough impregnation with an insulating wax. This thorough impregnation is a matter of considerable difficulty, on account of the fact that the slate will frequently decrepitate on being heated to the necessary temperature, and in consequence the expense of impregnated slate is very much beyond that of the untreated material.

---

* A Paper read before the San Francisco Convention of the Pacific Coast Electric Transmission Association, February 15, 1898.

Porcelain is a material upon which we rely so much for insulation in difficult places that one would naturally expect to find some use of it in switchboard construction, but up to the present time no porcelain manufacturer has succeeded in making flat slabs larger than about ten inches square, and no one has carefully undertaken the construction of a switchboard framed in metal or wood and faced with porcelain. Such a construction might indeed be a cheap and thoroughly satisfactory one, but there are still a number of difficulties to be encountered which can be undertaken only by a switchboard manufacturer. Large glass slabs would be admirably adapted to this service, but unfortunately this material is too difficult to work and in consequence the expense of a glass switchboard properly drilled for the instruments and connections would be very great indeed.

On account of the difficulties which have been met in the employment of every other material for switchboard construction, marble has come to be considered as the standard material for this service, and if the marble be obtained free from metallic veins, it is entirely satisfactory. It has the advantage of a sufficient strength to stand whatever shocks may come from throwing switches. It is not porous to any appreciable degree and it may be found in many colors, so that it is easy to obtain marble in which the instrument facings may form a sharp contrast and be readily read from all parts of the station. The relative advantages of native and European marbles involves not simply the question of beauty and evenness of texture, which are the points considered in marble carvings, and statuary work, but also the question of an absolute freedom from metallic veins, which is a property of the pure white Italian marble. Furthermore, no other marble is so easily kept clean, nor is any other found with which the instruments give so sharp a contrast, and, where the expense is not prohibitory, the use of this marble is to be favored, but at the same time, should its cost be very great in comparison with that of native marbles, a careful consideration of the color of the instruments and the instrument scales should result in contrasts which would be sufficiently striking for the instruments to be easily read and manipulated.

After the material of the board itself, the switchboard circuits are the most important item in construction, and the most important question in the consideration of circuits is that of the proper character of the insulation to be employed. In this service, everything should give way to fire protection, the weatherproof character of the insulation being entirely a secondary consideration. These circuits when definitely located are rarely laid flat along the surface of the board, and never touch one another, nor is there likelihood of the switchboard ever being wet with water, and in consequence any insulation which gives satisfactory protection against damage from accidental contact will be satisfactory, if at the same time it is impossible to ignite it. Sparks may fly at any time from switchboards, and always do fly at some time, whereas at this point a conflagration which at any other part of the system might be considered as insignificant, is apt to result disastrously. Slight switchboard fires have wrecked dynamos and engines and have even consumed large plants. Indeed, the effect of a small switchboard or station fire need not be emphasized to those who remember the destruction of the Brush station in New York and of the station at Hartford, Conn., and the recent destruction in Philadelphia of the Traction Company's plant by a short circuit at a dynamo. For this same reason care must be taken in the location of the circuits both on the board and those leading to the board. This is especially important in high potential working, for in this service heavy long arcs may occasionally be drawn which are attracted by some of the wires, and in consequence if the wires leading to the board, or the wiring along the board be carried over switchpoints from which long arcs may be drawn there is great danger of the wires themselves catching fire, and even of their being entirely fused.

While therefore, the fireproof character of the insulation for a switchboard and for station circuits is of the first importance, it must not be forgotten that it is everywhere advisable that all parts of high potential circuits should be either well insulated or so hidden that accidental contact is impossible. More than one man has been injured at a high potential board by stumbling and trying to catch himself, consequently it is not only sufficient to place the switch-points behind the board, so that the switch handles may be safely worked, but it is also necessary to protect these switch-points in such a manner that rapid connections behind the board may always be performed without danger of contact with deadly circuits. This necessity was fully recognized by Mr. Ferranti in all of his high potential work, and it is to the credit of his foresight that so few accidents have occurred in plants that he has installed.

In low potential working great insulation of switchboard circuits is not necessary and hardly even advisable, but it is rather necessary that low resistance and good lines and good contacts at all junctions should be assured. Low resistance now means not only a large area of copper, but also good heat radiating surface, so that the wires may remain at their normal temperature even when carrying large amounts of current. Various experimenters have proved that a black surface will radiate heat twice as well as a white surface, and in consequence the common practice of polishing and lacquering bus bars and switches is not only an extravagance, but a bad practice from an engineering standpoint.

As regards the manner of the switchboard wiring, it is at the present day hardly necessary to insist upon careful workmanship, but if the board is to be considered as the influential point in the station even more than common attention should be paid to this question, and especially it should be insisted that all work on switchboard circuits, whether intended to be only temporary or for permanent use, should be done in the best possible manner,—and if this be insisted upon the busy superintendent will find at least one point at which he can carefully observe the manner in which the linemen are accustomed to do their work. Furthermore, temporary switchboard circuits imply station changes, and station changes bring with them a period of possibility of accident greater than usual, which accidents must, mainly be corrected at the switchboard, where a few temporary and badly run wires might multiply little station difficulties to a disastrous extent. Furthermore, it should not be forgotten that temporary work often remains for years in the busy central station.

The instruments themselves show perhaps the reason for the existence of the switchboard, but are here put down in the third place of importance, because errors likely to occur in the choice of instruments are not so important as errors commonly made in the choice of switchboard material and in the construction of switchboard circuits. In aiming at simplicity of design and ease of working about the switchboard the principle may be laid down as regards to instruments that no more should be installed than are necessary for the manipulation of the plant and for obtaining a daily or hourly log report on its operation. This implies perhaps a few more instruments than are absolutely necessary for the manipulation of the plant. At the same time the log gives the only true data for an engineering test of plant operation. Tests under test conditions always give results more or less ficticious. Every man is, as the saying goes, at "test pitch." He desires to show his maximum efficiency, and the maximum efficiency of the machines with which he is working, and in consequence the occasional test of a plant will give results better than those obtained from actual service. On the contrary, the log gives a report by means of which may be detected those little leaks which eat into the profits and which indicate a falling off in the efficiency of either men or machines. No good man will neglect repair or fall off in efficiency if he knows that he is continually checked up by a log, and also wheels and bearings may become disarranged without giving other notice than can be found in such a test report. It is indeed true that every station superintendent is not capable of properly interpreting a log, but the best man is without data for careful reasoning who has not such a report at his command.

Whatever instruments may be installed their arrangement is of the greatest importance, but if the general criterion be applied to all switchboard designs that all switches and rheostat handles and other apparatus of manipulation be placed at convenient levels for handling and that all related instruments be grouped so that they may be easily observed the best results will be obtained. These ideas are so obvious that it may seem strange to bring them forward, but it is even stranger to find that they are so often disregarded. Large and expensive boards are often found where the same man cannot at once manipulate a machine rheostat and observe the effect he is producing upon the instruments. Much of this ill arrangement comes from a mistaken idea that the resistance boxes must be located on the switchboard and within a few inches of the rheostat handles, and in consequence more consideration is devoted to economizing the space on the board than for the convenience of those who are called upon to manipulate the apparatus. Not only may rheostats be operated through the medium of a sprocket wheel and chain, but also it is possible and not necessarily expensive to locate switches at a distance from the operating handles, and if these points be taken into consideration, the excuse for inconvenient location of related apparatus disappears. A worse practice than this, however, consists in the placing of fuses, circuit breakers and switches likely to flash, at points where they become elements of positive danger to the operators or to the circuits. Here again it is necessary to insist on the fact that the switchboard must often be rapidly manipulated and the service saved at the risk of some personal danger, which cannot be encountered with fuses and circuit breakers and switches flashing in the workman's face, and sending up arcs which burn off his circuits. This question of the separation of instruments and the handles by which they are worked reduces some of the difficulties of switchboard location and some of the dangers connected with high potential working, for by these means it is not only possible to install a safe board which can be placed far away from a wall by placing the switches to the rear of the board and the handles in front, but it also allows the location of all apparatus vertically above the manipulating handles, and at the same time, on the face of a tall board placed up against a wall. If this is done, however, the board must be tall enough to allow a gallery for the manipulation of circuits, and the old custom of making circuit changes from ladders should not be contemplated.

Finally the question of the proper location of a switchboard is perhaps the most perplexing of all the points in the station design. The board may be placed anywhere, and for this reason there is a certain temptation to disregard its location in the original plan of the station, but if it is to be considered as a center of influence, and if it is to be considered as a point at which rapid changes can be made which will certainly preserve the service in spite of accidents to lines or machines, it must be placed prominently and so prominently that all work about it may be easily seen as well as so prominently that the station attendants may watch it for their guidance. The board should then be clearly lighted, the space about it on all sides should be sufficient for careful and rapid work, but above all it must be carefully surrounded by a space insulated from the ground. The fact that the switchboard is set on edge and towers into the air does not warrant the assumption that it does not need a clear floor space about it. Neglect of this consideration has often resulted in unreliable service, which transmission plants cannot contemplate. With the introduction of long distance power transmission the time has passed for the occasional temporary interruption of service, and until machines and lines may be built which will never fail, the switchboard will remain the one point from which it is possible in almost all events to maintain absolute continuity of service.

There is nothing particularly novel in what has been said here—nothing which all have not known from their studies or from their experience, and if there is nothing novel, there is all the more reason that these suggestions should be emphasized, for they are not always carried out in stations which are considered well designed. Furthermore, the merit of a suggestion does not consist in its novelty, and we are already injured in our electrical engineering by a too great striving after novelty in much of the designing which we meet in heavy practice, and it is here intended to call attention to only some of the points of good engineering, which have been proved to be good and necessary by the experience of the past in the central stations which have already been erected and which may serve as the best guides for the construction of transmission plants, which differ from the common central station principally in the demand for absolute continuity of service. Transmission plants, to be entirely successful, must be so constructed that the service will never fail, and for such absolute continuity of service it is necessary to consider the switchboard even more thoughtfully than the careful engineers of the past have considered this vital element in the generating station and the sub-station.

"I must compliment you on your Blue Lakes Edition—it is a credit to technical journalism and will no doubt bring you many congratulations. Please enter my name as a subscriber," writes Mr. W. L. Honnold, San Andreas, Cal.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity, Gas and Power.

OFFICIAL ORGAN OF THE PACIFIC COAST
ELECTRIC TRANSMISSION ASSOCIATION.

SUBSCRIPTION PAYABLE IN ADVANCE. TERMS—DOMESTIC, ONE DOLLAR
PER YEAR; FOREIGN, TWO DOLLARS PER YEAR.
RATES FOR ADVERTISING ON APPLICATION.

The trade supplied by the San Francisco News Company.

EDITED AND PUBLISHED BY GEO. P. LOW.

Business Office, 516 COMMERCIAL ST.
Telephone, Steiner 62[illegible].

Address all communications to
Editorial Rooms, 427 TENTH AVE

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME V. FEBRUARY, 1898. NUMBER 5

EDITORIAL.

CONCERNING ELECTRICAL CHARLATANS.

The article contributed by Mr. Sidney Sprout on "A Fraud Upon Electricity," appearing on another page, suggests the bounden duty of electrical journalism to denounce in the strongest terms every effort that may be made by schemers who so often succeed in inducing capital to invest in so-called theatrical enterprises that really have nothing electrical of merit about them and which are, therefore, from an electrical standpoint at least, of a fraudulent nature. The promoters of wildcat schemes have but little knowledge of electrical matters, and all know that a little knowledge is a very dangerous thing—nevertheless, the general run of investors are not able to discern the facts and, being inevitably victimized, their minds are poisoned against the science of electricity as an investment and the whole industry suffers. Indeed, the time has come when the technical press to a unit should denounce all jobbery of the electrical industry as it would a pickpocket.

The injury that has been inflicted upon the electrical industry by reason of fraudulent schemes in which miracle workings have been attributed to electricity, can never be estimated in money value for the reason that the injury is hidden in the form of suspicion and distrust of the legitimacy of many worthy electrical enterprises, as well as beause of a doubt that investment in an electrical enterprise is neither more nor less than embarking into an unknown sea in an untried, if not unworthy craft. Untold millions have been irrevocably sunk deep in the mire of the slough of electrical fakirism, and money is never lost without the shattering of some confidence or other. Capital has a discernment distinctively its own and its eyes, however keen in the world of finance, are little less than blind when in the atmosphere of electro technics.

One may, if clever in mental gymnastics, conjure up a harmless belief that electropoise cartridges, electric hair-brushes and electric insoles possess a consecrated ability to relieve pain, or to make bald heads hairy, or to warm feet that tend to chronic coldness, but the truth is that bread pills will prove equally efficacious if the patient has abiding faith in the physician who administers them. There is no suggestion of an electro-therapeutic property in even one-hundredth of the pseudo-electric cure-alls that are on the market, yet the subtle magic suggested in the word "electricity" charms away the common sense and dollars of the public, giving in return an imaginary alleviative that is electric only in name. But the public believes that electricity exerts some potent influence for good through the inert article that has been bought and reposes secure in an undefinable confidence that the "subtle fluid," though strange, is an exceedingly considerate genius—an administering angel truly. The fact is that the cures of electro-quackery are those of the well-masked influence of mind over matter, and electricity, like a flower of spring, has nothing to do with the case.

The lies of electro-quackery are white lies, for they generally go no further than to practice faith cure by disguised methods. They merely give the rose another name, even though, to electricians, that name suggests dank unsavoriness. But the lies of electro-fakirism are black lies, without a solitary redeeming trait, and their only purport is the ulterior one of inveigling capital into spurious electrical ventures, and, when all is lost, capital attributes its misfortune to electricity without discerning the spuriousness of the scheme or realizing the perfect innocence of the so-called "infant science." No one will gainsay the fact that fraudulent enterprises of a pseudo-electrical nature have fleeced capital out of many of its millions until capital, in turn, is prone to view with deep-rooted suspicion any electrical project, however meritorious.

It is this unfortunate condition of affairs that has caused many a legitimate electrical project to languish or be dropped altogether because of inability to interest capital in its development. On the other hand, capital appears to lend a willing ear to electro-jingoists, and it is a blessing that its unfortunate experiences are slowly teaching it that there is no magic about the word "electricity;" that its applications must meet all other industrial agencies on a neutral ground, where it must hold its own or be vanquished from the field of commercial supremacy.

Capital must study projects of an electrical nature from an electro-technical standpoint, as well as from the more familiar standpoint of financial or commercial feasibility, if it is to protect itself from the all-devouring sharks of electrical fakirdom.

STATION SWITCH-BOARDS.

Dr. Perrine's paper on Central Station Switchboards, presented to the San Francisco Convention of the Pacific Coast Electric Transmission Association, finds its great value in the emphasis it lays upon the necessity of surrounding the most vital, if not the most vulnerable, portion of the equipment of the power house with every possible safeguard, be it in the means for dissipating static charge, or in restricting arcing, liability of personal injury and the inflammability of the switchboard itself. Well is it stated that while there is nothing novel imparted by the paper, there is all the more reason that the suggestions contained therein should be enlarged upon and faithfully executed, for they are not always carried out in stations which are considered well designed. There is always room for the discussion of a theme of such general interest as that of switchboards and switchboard construction, and while one is in consonance with the treatment of the whole subject, he will be conscious that it sets forth one or two ideas with which his experience is not in entire accord.

Valuable indeed, however, are the speculations made in reference to the materials which may be used for switchboard building and to have concisely stated, as is there done, the advantages and disadvantages possessed by wood, slate, lava, marble, glass and porcelain for this class of work. Wood is inflammable, slate contains metallic oxides, lava is not available commercially, glass is expensive to work and porcelain can not be made in sufficiently large slabs. Thus is it then that marble is the most preferable because of its low cost, its ease of working, its non-inflammability, its non-metallic nature and its finished beauty of appearance. Some interest was awakened during the discussion of the paper by the suggestion that for low potential work, a good material for switchboards would be found in composite tiling cemented in a metallic frame, but the great difficulty of drilling tiling seemed responsible for its disapproval and the opinion which prevailed regarding its use was summarized in a pertinent observation by Mr. Beal who understood the tile question to be that one "must first get the hole and then put the tile around it."

There is yet, however, considerable room for improvement in methods of treatment and use of marble in building switchboards, and much remains to be investiagted concerning the hygroscopic properties of marble, the action of direct currents on marble, the filling and polishing of marble, and concerning the influence which dust, settling on its generally unpolished back, exerts on the resistance of the marble board. These are among the important points brought out by a consideration of Dr. Perrine's paper. Prof. Cory states emphatically that marble is neither non-porous nor non-hygroscopic, and in support of this conviction, cites a series of experiments made by himself in which he found it necessary to get a resistance which would be of the nature of from thirty megohms to one thousand megohms for the purpose of testing the capacity of a condenser, and the materials tested for this resistance were slate, polished and not polished, japanned and not japanned, waxed and not waxed; marbles of various qualities; common porcelain, and high potential insulator porcelain. He found that an interesting thing about all of these was the difference in resistance at different temperatures, and that the resistance depended upon what had been the previous history of the material. He had a piece of Italian marble which was brought from a dark, cold basement where it had laid for three years untouched. It was tested and its resistance was found to be about thirty megohms; the marble was then placed on the cylinder head of a steam engine for a few minutes and again tested when its resistance was found to have increased to above one thousand megohms, the limit of the scale of the galvanometer. These experiments were repeated and the conclusions verified by the use of high voltage tests, and the conviction was reached that marble is both porous and hygroscopic.

The increased potentials used on long distance transmission lines and the necessity of constructing switchboards for controlling these extreme voltages will compel a more careful study of what may be termed the elusive properties of marble, than has heretofore been given. Moreover, it is very evident that there is necessity for polishing every portion of the switchboard instead of polishing the front alone, as the present universal practice. Neither dust nor the volatilized metal from fuse blowings or other arcings will impregnate polished marble, and in addition, filled and polished marble may be rendered practically impervious to the ordinary agencies that at present remove it to some slight degree from the proud position of being the perfect material for switchboard building. While the reduction of marble to lime by electrolysis may be theoretically possible, it certainly has not become manifest in practice and the use of alternating currents will minimize electrolysis to a negligible factor, if not to nullify its evil tendencies altogether.

The blackening of bus bars so as to faciltate the dissipation of heat and, in so doing, to increase their conductivity by reducing their temperature, is a point well taken, but the inference expressed that the water-proof character of the insulation used on switchboards may be sacrificed for the purpose of attaining non-inflammability, will doubtless be disputed on the tenable ground that waterproofing and fireproofing go hand in hand—that no non-waterproof circuit is proof against causing fire, or, to put the same statement in another light, that no non-fireproof circuit is absolutely fireproof if unable to resist the encroaches of moisture, that insidious but infallible forerunner of that oft-times incarnate fire-producer, electrolysis. Nor is it reasonable to contend that there is no likelihood of a switch-board ever being wetted, for a condition of permanent, absolute dryness can seldom, if ever, be assured. Fresno rested secure in the belief that it was beyond reach of a water damage until the bursting of an eighteen-inch underground main tore down its brick wall and, reaching an arc switchboard and the step down transformers, flooded its sub-station. It is the unexpected that always happens and one must not forget that water in one form or another, is omni-present.

The question of inflammability of insulations has been threshed over so thoroughly that further discussion of it seems redundant. With the utmost brevity may it be stated, however, that strictly high grade insulation without the use of an inflammable covering, has not yet been attained. Such insulation is necessary to insure safety to life and property and the only disadvantage to be found in its use is that when ignited, it will carry fire. Then why not sheath it with a non-ignitable material, which will eliminate its only incendiary proclivity. Both fire-proofing and water-proofing, the two prime requisites for securing immunity from fire, will thus be afforded without either working to the disadvantage of the other.

FATALITIES FROM LOW-VOLT SHOCKS.

Four cases of death from electric shock occuring in a single chemical factory, the name of which is purposely withheld, are recorded in a German contemporary "Elektrotechnische Zeitschrift," of December 30th last, and the extraordinary feature is the statement that the fatal pressure could not have exceeded 230 volts alternating current! It appears that in the first instance the unfortunate man was standing barefooted on the ground turning a reel that raised an arc lamp, when a terminal of the lamp came in contact with a pulley that grounded the circuit through the workman. In the second instance the victim leaned out of a window and deliberately seized an overhead circuit outside; in the third case a live wire came in contact with an ungrounded metal pipe which contained it, the shock being given from the pipe; and in the fourth case the shock was attributed to a faulty flexible conductor or lamp fitting.

The article referred to is unsatisfactory in that in one portion it defines the circuit in question as being "a 230-volt three-phase system, mesh connected," while in another portion it states that "at all events in three out of the four cases the pressure to which the victim was subjected did not exceed 115 volts." Evidently then, the secondaries were in "Y" connection with 115 volts on a side, in which event the maximum circuit potential would be but a fraction under 199 volts ($115 \times \sqrt{3} = 198.9$ volts.) The exception referred to was probably the case in which the victim leaned out of the window, probably grasping two wires of a Y connected three-phase circuit, giving him a 200-volt shock. The other three cases seem to have been from 115 volts as stated. The four deaths occurred from the same wires within a period of sixteen months.

Startling as this experience is, there is no need for serious alarm as in all probability in extraneous causes will be found an acceptable solution of the apparent mystery. It is stated that the installation was placed in a thoroughly workmanlike manner, that tests had shown the insulation resistance to be high, but that considerable dampness existed. A leakage of high tension current from primary to secondary may have developed periodically by a "swinging cross" so that through coincidence, or rather through the absence of it, the grounding of the transformer may have escaped detection. Where deaths have occurred from low pressure shocks it has usually been considered that they were due to a weakened or affected physical condition, abetted by a good contact. The evil of good contact was evidently present in all of the fatalities cited and it is perhaps more than probable that the employees of the establishment were so emaciated if not diseased from the long-continued handling of chemicals that they were peculiarly susceptible to shock, with the result stated. It is not probable that a person who is salivated, for instance, would withstand a very severe electric shock.

Though these fatalities are deplorable, they cannot in any manner of reason, constitute an arraignment against the potentials that have been so universally adopted for both direct and alternating current distribution. Rather is it an arraignment of our civilization that has not found a means to avoid the sending of fellow beings to the living death of labor in certain forms of chemical factories.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

THE "KILOVOLT-AMPERE."

The electrical engineering world is indebted to Steinmitz for the coining and introduction of a new and timely term that seems so natural and simple that the wonder is the need for it has not resulted in its creation long ago. The word referred to is "kilovolt-ampere," and the distinction between it and the familiar term "kilowatt" is at once apparent to all who have had to do with the exact measurement of alternating current. The kilovolt-ampere has come to stay and its arrival marks another of the few final steps that remain to be taken before the category of electrical nomenclature shall have been fully completed.

A CHANGE IN A CONTEMPORARY.

Congratulations are extended to the Electrical Review, the valued New York contemporary, on the reduction of the size of its pages to a more convenient dimension, as well as to its improved typographical appearance. The Review has a sphere of its own in which it is unapproached by any other electrical publication, and now that it is in handy form and otherwise improved, it is bound to be more prized than ever.

Pity 'tis that the electrical periodicals, like many of the publications of the engineering societies, can not be standardized in their dimensions.

Transportation

POLYPHASE MOTORS IN RAILWAY WORK.*

By Charles Proteus Steinmitz.

For controlling polyphase railway motors three methods are available:

First—Rheostatic control.

Second—Tandem-multiple control.

Third—Potential regulation, with short-circuited motor armature.

First—In rheostatic control the armature or secondary circuit of the motor is supplied with collector rings, across which the rheostat is connected. A rheostat in the main or primary circuit would reduce the torque per ampere proportionally to the reduction of voltage, due to the decrease of magnetization of the motor, and thus this method is not suitable for railway work. The advantages and disadvantages or rheostatic control are the same as on the direct-current system. The system is very simple, and the motors are satisfactory and efficient at full speed, but in starting and at low speeds power is wasted in the rheostat.

Second—Tandem-multiple control. Two induction motors in concatenation, that is, the secondary of the first motor feeding the primary of the second motor, reach their synchronous speed at half the synchronism of the alternating-supply current, that is at half the speed at which they would run in parallel connection. This method thus gives the same features as series-parallel control on continuous-current motors; that is, it approximately doubles the torque and saves the power wasted in the rheostat below half speed and reaches full efficiency at half-speed. Obviously, just as in series connection of continuous-current motors, the efficiency at half-speed is not quite the same as at full speed and parallel connection, since with the same torque the losses in the former case are double. Still, the efficiency with this method of connection is far superior to that attained by rheostatic control, and the starting current is less, but the controller is somewhat more complicated.

Third—The potential regulator offers the simplest arrangement. The motor has no collector rings, but a short-circuited high-resistance armature, giving maximum torque in starting, and the torque and thereby the speed is varied by varying the impressed voltage at the motor terminals. This is done by a potential regulator; that is, a transformer, or rather compensator, of variable ratio of transformation. Unfortunately with such a motor the efficiency at speed is lower than when rheostatic control is used and the apparent torque efficiency that is, the torque per ampere, is very low in starting. The motor requires in starting at least twice the current for a given torque that it would require with rheostatic control. Considering now that the starting torque of a railway motor must be at least from two to three times the running torque, the starting current with the potential regulator method is about four to six or more times the running current. Since, however, the torque of the motor falls off with the square of the voltage, still more current is required in starting, on account of the drop of voltage caused in the lines by the excessive starting current. In consequence of this if the drop in the lines is not very small, even at heavy overloads, the motor is liable to be stalled or to fail to start. In consequence thereof the potential regulator control, while apparently the simplest, is entirely unsuitable for most railway work, or any other work where heavy starting torque is required and the supply of power is not unlimited as compared with the size of the motor.

Comparing the relative advantages and disadvantages of polyphase and of continuous-current motors for railroading, we have as the foremost and dominant advantage of the continuous-current motor that it is standard apparatus, familiar to and well understood by everybody, and capable, with the help of rotary converter substations, of being used on roads at any distance from the power station. It requires a single trolley only, while the three-phase motor requires a double trolley.

On long-distance roads, however, the continuous-current motor requires rotary converter sub-stations, which need some attendance, while the polyphase motor only needs stationary transformers distributed along the line.

In starting, acceleration, efficiency, etc., both types of motors are about equal. In operation the polyphase motor is somewhat more reliable, due to the main current entering the stationary member only, and to the absence of the commutator. This advantage of the polyphase motor, however, is probably about offset by the greater familiarity of most people with the direct-current motor.

With the same voltage the three-phase railway system requires more copper in the lines, since the drop of voltage with the same current and size of conductor is greater in the polyphase system, being the impedance drop against the resistance drop with the direct-current system. A lesser drop of voltage in the lines must also be chosen in the polyphase system, since the torque of the motor decreases with the square of the voltage. Since, however, the three-phase current enters the stationary member of the motor only, and no commutator is used, a much higher voltage can be chosen in the trolley lines of the three-phase road than is permissible in a continuous-current road.

In the continuous-current motor the speed varies with the load, while the polyphase motor can maintain its speed irrespective of the load, and is thus better suited to keep its schedule time under all conditions of traffic. Hence, it is preferable for long-distance or interurban roads with single-track lines. In the polyphase motor all difficulties with the commutation are absent, and the structure of the motor is simpler, thus making it specially fit for heavy high-speed service, or for heavy service in general, as for hauling express or freight trains up grades, which are too steep for the steam locomotive to surmount them.

---

*An abstract from a contribution to the Electrical World, Vol. XXXI, No. 1.

Fraternal

THE TRANSMISSION ASSOCIATION.

The San Francisco Convention of the Pacific Coast Electric Transmission Association was held in the offices of the Blue Lakes Water Co., in the Crocker Building, on February 15th, and the time of the open meeting of the Association was taken up in the reading and consideration of the paper of Dr. F. A. C. Perrine on "Central Station Switchboards," which is presented elsewhere in full.

During the executive session the following was adopted as the Constitution of the Association:

ARTICLE I.

NAME.

The name of this organization shall be "The Pacific Coast Electric Transmission Association."

ARTICLE II.

OBJECTS.

The objects shall be the collection and dissemination of information relative to the generation, transmission, distribution and utilization of electric energy, the discussion of all topics of kindred interest and the promotion of the best interests of its members.

ARTICLE III.

MEMBERSHIP.

The membership shall be divided into three classes, viz.:"Regular Members," "Associate Members," and "Honorary Members."

REGULAR MEMBERS.

Any corporation, firm or individual engaged in the generation and long distance transmission of electrical energy, and not engaged in the manufacture or sale of electrical apparatus or supplies, except the supplying thereof to customers of the transmission plant, shall be eligible to regular membership and shall become a regular member upon being nominated by a regular member and elected by a majority vote of all the regular members present at any regular or called meeting of the Association and the payment of membership fees and dues as hereinafter provided.

ASSOCIATE MEMBERS.

Any corporation, firm or individual engaged in the distribution of electrical energy, or engaged in the manufacture or sale of electrical apparatus or supplies, or any electrical, mechanical, hydraulic or civil engineer shall be eligible to associate membership, and shall become an associate member upon being nominated and elected and making payment of fees and dues as above provided with regard to regular membership.

HONORARY MEMBERS.

Any electrical, mechanical, hydraulic or civil engineer, or other person whose attainments or services to science shall merit the distinction, shall be eligible to honorary membership, and shall become an honorary member upon being nominated and elected as above provided with regard to regular members.

ARTICLE IV.

FEES AND DUES.

The fees and dues to be paid by the members of this Association shall be as follows:

REGULAR MEMBERS.

Regular members shall pay a membership fee of Ten (10) Dollars upon being elected, which shall be in full for their membership fee and of all dues until the next ensuing annual meeting. Annually after their election, or the first day of July each year, they shall pay the sum of Ten (10) Dollars as and for annual dues

ASSOCIATE MEMBERS

Associate members shall pay a membership fee of Ten (10) Dollars upon being elected and annual dues of Ten (10) Dollars on the first day of July of each succeeding year.

HONORARY MEMBERS.

Honorary members shall be exempt from the payment of all fees and dues.

ARTICLE V.

REPRESENTATION.

Each regular and each associate member shall be entitled to one representative at all regular and called meetings of the Association. Such representative to be a regular employee of such a member. Provided, however, that no regular member shall be entitled to send as representative any person who is engaged in the manufacture or sale of electrical apparatus or supplies. Also, provided, that associate and honorary members shall not be entitled to representation at the executive meetings of the Association. Honorary members shall be entitled to be present at all meetings of the Association other than executive meetings.

ARTICLE VI.

MEMBERSHIP PRIVILEGES.

The privileges attaching to membership in this Association are as follows:

REGULAR MEMBERS.

Regular members are entitled to participate in all meetings of the Association, to vote for the election of officers and new members of all classes, to serve upon committees, to participate in all discussions and generally to exercise all of the rights and privileges attaching to regular membership in similar associations.

ASSOCIATE AND HONORARY MEMBERS.

Associate and honorary members are entitled to participate in all meetings of the Association other than executive meetings and to present papers for consideration and participate in all discussions other than those relating to the business of the Association. No associate or honorary member shall be elected to any official position in the Association; be appointed on any committee thereof charged with the conduct of any association business or entitled to cast a vote.

ARTICLE VII.

OFFICERS.

The officers of the Association shall consist of a President and a Vice President, who shall be representatives of regular members of the Association, and a Secretary and a Treasurer.

WHEN ELECTED.

The officers of the Association shall be elected at the regular annual meeting of the Association, or at an adjournment thereof.

TERM.

The term of office of any officer of this Association shall expire with the election and installation of his successor in office.

DUTIES.

The duties shall be such as usually attach to corresponding officers in similar associations.

ARTICLE VIII.

EXECUTIVE COMMITTEE.

The President ex officio and two regular members of the Association appointed by him and confirmed by the Association in executive session shall constitute an Executive Committee, which shall meet at the call of the President or any two of its members, and shall have power between meetings of the Association to dispatch all association business; to call special meetings of the Association, and at their discretion to take a letter ballot of the Association upon any question, and to canvass the same and render effective the results thereof.

ARTICLE IX.

MEETINGS.

The meetings of the Association shall be held from time to time as hereinafter specified.

ANNUAL.

The annual meeting shall convene in the city of San Francisco, California, on the third Tuesday in June of each year at such nour and place as may be designated by the Executive Committee.

SPECIAL.

Special meetings shall convene at such time and place as is designated at the adjournment of any proceeding annual or special meeting, or at such time and place as may be designated in the call thereof.

CALLS.

Calls for special meetings may be issued by the Executive Committee and shall be issued by the President on the written request of a majority of the full members.

NOTICE.

The Secretary shall give all regular, associate and honorary members twenty days' notice of the convening of any annual or special meeting by written or printed notice mailed to their several addresses as indicated by the records of his office.

ARTICLE X.

QUORUM.

A quorum for the transaction of business shall consist of the President, or, in his absence, the Vice President, and two regular members, or in the absence of both the President and Vice President, shall consist of five regular members.

ARTICLE XI.

VOTES.

Each regular member shall be entitled to one vote at all elections and upon all questions pending before the Association. Associate and honorary members shall not be entitled to vote.

ARTICLE XII.

PARLIAMENTARY.

Roberts' Rules of Order shall govern all questions of parliamentary usage and proceedure not governed by these by-laws or by some resolution or order of the Association.

ARTICLE XIII.

ORDER OF BUSINESS.

Unless dispensed with by a majority vote of the Association, the following shall be the order of business observed at all meetings:

1. Calling roll of regular members.
2. Enrolling of associate and honorary members in attendance.
3. Reading minutes of preceding meeting.
4. Reports of officers.
5. Reports of standing committees.
6. Reports of special committees.
7. Nomination and election of regular members.
8. Nomination and election of associate members.
9. Nomination and election of honorary members.
10. Reading of papers on set topics and discussion.
11. Reading of papers on special topics and discussion.
12. Proposal of set topics for next meeting and adoption.
13. Miscellaneous business.
14. Election of officers.
15. Adjournment.

ARTICLE XIV.

DEFNITION.

No corporation, firm or individual shall be construed to be "engaged in the generation and long distance transmission of electrical energy" within the meaning of section III of these By-laws unless the distance of transmission between the points of generation and principal point of utilization shall be five or more miles, nor unless the voltage between wires of main transmission line shall be 5000 or more volts.

ARTICLE XV.

AMENDMENTS.

These By-laws may be amended by a majority vote at any annual meeting without notice, or at any special meeting, provided the member desiring to propose an amendment hereto shall file a (notice and copy of such proposed amendment with the Secretary) thirty days in advance of such meeting. In event a copy and notice of a proposed amendment to these By-laws shall at any time be filed with the Secretary as aforesaid it shall be his duty to cause copies thereof to be prepared and mailed to each full member simultaneously with notice of the next meting.

Personal

Mr. C. S. Knight, of the Fort Wayne Electric Corporation will be in San Francisco about March 1st.

Mr. J. B. Crockett, President of the San Francisco Gas and Electric Company, is in Mexico on a pleasure trip.

Mr. John R. Cole, San Francisco representative of the New York Insulated Wire Company, is in New York City.

Mr. J. W. Godfrey, agent of sales for the India Rubber and Gutta Percha Insulating Company of New York, was in San Francisco last week.

Mr. Henry E. Vineing, mechanical and electrical engineer of New York, and late master electrician of the Brooklyn Navy Yard is in San Francisco, engaged in the supervision of the erection of the steam and electrical installation in the new "Examiner" building.

Mr. A. M. Hunt, principal member of the firm of Hasson & Hunt, consulting mechanical and electrical engineers of San Francisco, is, it is reported, about to withdraw from the co-partnership to accept the position of engineer-in-chief for the very extensive interests of the Alaska Commercial Company. Who will succeed Mr. Hunt as engineer for the firm named is not known, but it is certain that Mr. Hunt will be the recipient of the warmest congratulations from his fellow engineers who, without exception, respect the genious and admire the man now about to be so happily and deservedly promoted to a more congenial and lucrative association.

Dr. Louis Duncan, Past President of the American Institute of Electrical Engineers, has been appointed electrical engineer of the Third-Avenue Railway Company of New York, and will have charge of changing the road into an electric line. Three years of time and about $6,000,000 will be required to make the change. Dr. Duncan will not give up his work at the Johns Hopkins University, and will continue to make Baltimore his home. His assistant, Mr. Sydney H. Browne, will remove to New York about April 1 to devote his entire time and attention to the great undertaking of which Dr. Duncan will have general charge. Dr. Duncan is one of the most popular and able engineers in the profession, and the appointment will bring out a universal approval of the selection that has been made for this most important piece of overhead electric railway work that has been undertaken in America.

Industrial

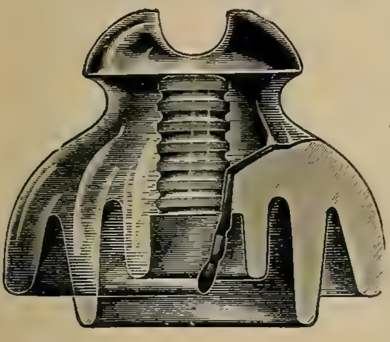
In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

EDISON LAMPS FOR ISOLATED PLANTS.

For isolated plants the General Electrc Co. have recently issued an incandescent lamp catalogue, which is something of a departure and which should be of special interest and value to all lamp users. This catalogue contains descriptions of the class of lamps used by Isolated Station plants. The omission of all other types of lamps has made the catalogue a simple, concise pamphlet. It is something more than a catalogue, in that it contains several opening chapters of special value to lamp users, discussing improved methods of manufacture and showing how important special experience and facilities are in the production of the highest quality of incandescent lamps. Following this, the subject of selection of lamps is discussed with the idea of assisting the customer to obtain the lamp best suited to his conditions. Then an account is given of the requirements for the proper use of lamps and a pertinent example figured out showing the saving to be effected by proper lamp renewals.

Following this are descriptions of the standard lamps as used by isolated plants, each description being accompanied by full sized illustrations of the lamps. Among others, the catalogue contains an account of 250 volt lamps. The catalogue is excellently gotten up, typographically, and contains a folder giving prices of the various types of lamps. The General Electric Co., have endeavored to send copies of this catalogue to every isolated plant in this country and will be glad to furnish copies to any plant or customer desiring the same. Such a useful treatise should be in the hands of every purchaser of incandescent lamps, and retained by them as a book of reference.

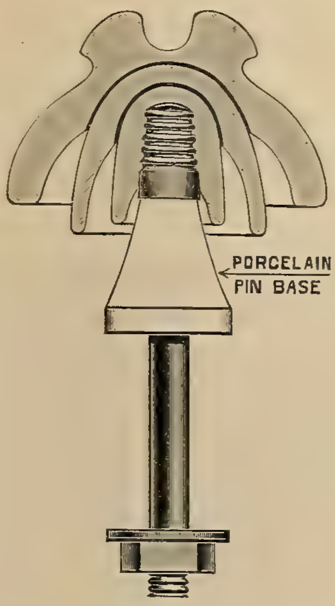
"LOCKE" HIGH POTENTIAL INSULATORS.



Much has been written and a great deal more has been said about the superiority of porcelain over glass in the manufacture of insulators for high potential circuits, on account of the knowledge that under ordinary conditions, glass was hygroscopic and more friable than porcelain. This was quite true of glass insulators, as ordinarily manufactured, and with a knowledge and clear understanding of these deficiencies. Mr. Fred M. Locke of Victor, N. Y., undertook their remedy, and as a result produced the insulator illustrated in this column. This insulator is very similar in general form to the familiar "Locke" No. 3, porcelain insulator, so largely used in California, but it is however considerably larger, being 5½ inches in diameter. The great point of difference between this insulator and other glass insulators lies in the fact that the Locke insulator is made of a tough glass, which after manufacture is carefully annealed, the product being an insulator which is as tough as porcelain and which it is practically impossible to puncture. While a laboratory test may develop considerable difference in the hygroscopic properties of the two materials, it is not borne out in practice, since the deposit of dust and dirt on the outer petticoats of insulators on a line practically eliminates this consideration. These insulators are now all sold subject to a guarantee to withstand a test of 50,000 volts.

These conditions, together with that of the actual cost, have resulted in the adoption of this insulator for all high voltage power transmission lines in California that have been built since it has been placed upon the market, and for electro-motive-forces as high as 20,000 volts. These insulators are to be used on the transmission line now being built over the Chilcoot Pass in Alaska, and also on the Goldstream-Victoria transmission line of the British Columbia Electric Railway Company; in this latter case the entire contract for line material having been placed with Mr. Locke.

There are still those who prefer procelain insulators. In very moist climates they are no doubt preferable, and for this class of work the "Locke" three part china insulator has been developed.



This insulator is made up of three glazed shells of vitrified china, glazed inside and out and then fused together to form a single insulator, as shown in the accompanying cut, being thoroughly vitrified before glazing. Should the glass be injured by impact or otherwise, by reason of its vitrification the insulator will not absorb moisture. These insulators recently withstood a dry test of 72,000 volts and a wet test of 54,000 volts, at which voltages the arcs followed around the petticoats. The test showing conclusively that porcelain insulators manufactured in this way are capable of withstanding the high voltages now in use or in contemplation.

The cut of this insulator here shown also illustrates the "Locke" steel pin with a porcelain base. The heavy copper wires used in transmitting large blocks of power have necessitated radical improvements in line construction and the old and familiar oak pin, one and a half inches in diameter has had to be discarded in many cases. Boring the cross arms for these large pins materially weakens them, and even where it is possible to increase the cross section of the arm, the wood pin itself is a source of weakness, not only on account of the strains introduced by the weight of the wire supported, but also on account of its liability to be burnt off by the static discharges between the insulators and pins. These difficulties have been met by the "Locke" pin, which is a steel pin with a wood top and a vitrified and glazed porcelain base, which extends from under the petticoat of the insulator to the cross arm. The steel pin is 7-16 in diameter, and only a ½-inch hole in the cross arm is necessary, and since the porcelain base receives all static discharges, no burning of the cross arm or pin is possible. This is not merely a theoretical condition, but is an actual one that has been demonstrated by experience in many cases.

These pins are to be used by the Southern California Power Company for their 33,000 volt transmission into Los Angeles; the San Joaquin Electric Company's 20,000 volt transmission to Hanford, Cal., and by the Yuba Power Company on their 16,500 volt transmission to Marysville, Cal.

Mr. Locke is represented on the Pacific Coast by Mr. Jno. Martin, 300 California Street, San Francisco, where samples may be seen.

AN INVALUABLE BOOK FOR LAMP USERS.

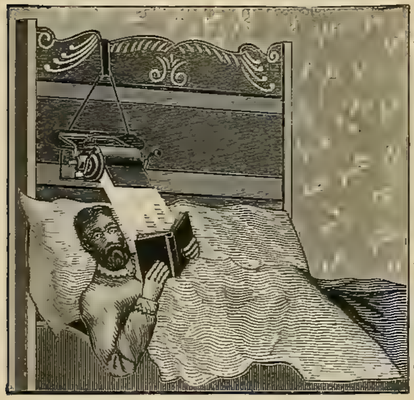
A catalogue recently issued by the General Electric Company forms the most complete publication of the kind ever produced, being nothing more or less than an exhaustive treatise on Incandescent Lamps from the customer's point of view. The catalogue begins with introductory chapters on the "Production, Selection and Use of Lamps," in which are set forth in a concise, telling manner the methods which have given the Edison lamp its marked superiority, as well as an account of the importance and value of skill and experience in lamp production, and how to select the type of lamp best suited to the purchaser's conditions, together with the necessary requirements for the proper use of lamps. Descriptions of the various types of lamps follow the introduction and a full sized illustration accompanies each lamp described. The descriptions and illustrations include every class of lamp manufactured by the General Electric Company, of which there are over 30,000 varieties, including the various voltages and candle powers, etc., and of which there are produced and sold annually over 6,500,000 lamps.

Following the description of the lamps is an "Appendix of Information on Incandescent Lamps" of great value to all lamp users. The opening discussion is on the "Life and Candle Power of Lamps, in which the subject of decline of candle power and its bearing upon the lamp renewals is clearly set forth. Following this is a chapter on the "Importance of Good Regulation," and additional chapters on the "Method of Measuring Lamp Value by Candle Power and Area," "Special Points to be remembered in the use of Lamps," "Faults in Incandescent Lamps," and tables of lamp data. The concluding chapters of the appendix are given to the subject of "General Illumination," the "Correct Use of Light" and "How to Avoid Harmful Effects on the Eyes."

Altogether the catalogue is the most complete and interesting commercial treatise on incandescent lamps ever produced. Its typography is excellent and the illustrations of the lamps are well designed and executed, making it altogether a valuable and useful book of information and reference. Copies have been sent to all station managers in the United States and can be obtained from the General Electric Company's Lamp Works, Harrison, N. J., or at the nearest local office.

In this connection, the General Electric Company desires to advise all holders of this Catalogue (No. 1012) of an error in the appendix, in the table on page 58. The figures .662 in the column "Life Factors" should be .562. The company kindly requests that all holders of the catalogue make this correction.

SPECIALTIES IN INCANDESCENT LAMP SHADES.



The Pacific Electric Company, of La Crosse, Wis., has made such a thorough study of the science of perfecting appliances for delivering incandescent light just where it is wanted, that it has become a specialist of national reputation in that particular direction. It has perfected a great many unique designs of what might be called "lighting novelties," one of which is illustrated herewith.

As is evident, this novelty consists of a "Bed Lamp," that is an incandescent lamp by which to read while in bed, and its eminent utility will be appreciated by all who are given to enjoying the satisfaction of reading "just a page or two" before going to sleep. Invalids, too, can find comfort in reading with this Bed Lamp when it would be impossible to do so otherwise, for the reason that the light is delivered directly on the page, so that reading is made easy without imposing strain of any nature on the eyes.

In all, there are ten or more different styles of these shades, suitable for use as parlor, piano, typewriter, standard or student lamps, or, if desired, the shade may be fitted for attachment into electric light sockets. Great attention has also been given to the perfection of the details of special swinging arm styles of shade lamps, suitable for physicians', surgeons' or dentists' uses, as well as for the use of the library or study.

Descriptive pamphlets of these useful devices will be furnished on application to the Pacific Electric Company, 120 Main street, La Crosse, Wis.

TABLE OF CONTENTS.

Illustrated articles are indicated by an asterisk (*)

Editorial

Concerning Electrical Charletans 101
Fatalities from Low-Volt Shocks.. 103
Station Switchboards.... ... .102

Authors

Perrine, Dr. F. A. C. 98
Rix, E. A....... 95
Sprout, Sidney.... 93
Steinmetz, Charles Proteus.. .. ..

Gas

A Fraud Upon Electricity, by Sidney Sprout........ 93

Electro-Economics

Central Station Switchboards, by Dr. F. A. C. Perrine, D. S. C..... 98

Transmission

*The Newcastle-Sacramento Transmission...... 89

Pneumatics

*Compressed Air at the Utica Mine, by E. A. Rix.... 95

Transportation

Polyphase Motors in Railway Works, by Charles Proteus Steinmitz.... 104

Passing Comment

The "Kilovolt-Ampere"..... 103
A Charge in a Contemporary...... 103

Fraternal

The Transmission Association... 105

Personal

Industrial

*New "Locke" Line Specialties.... 107
Edison Lamps for Isolated Plants.. 107
An Invaluable Book for Lamp Users.... 107
*Specialties in Incandescent Lamp Shades 108

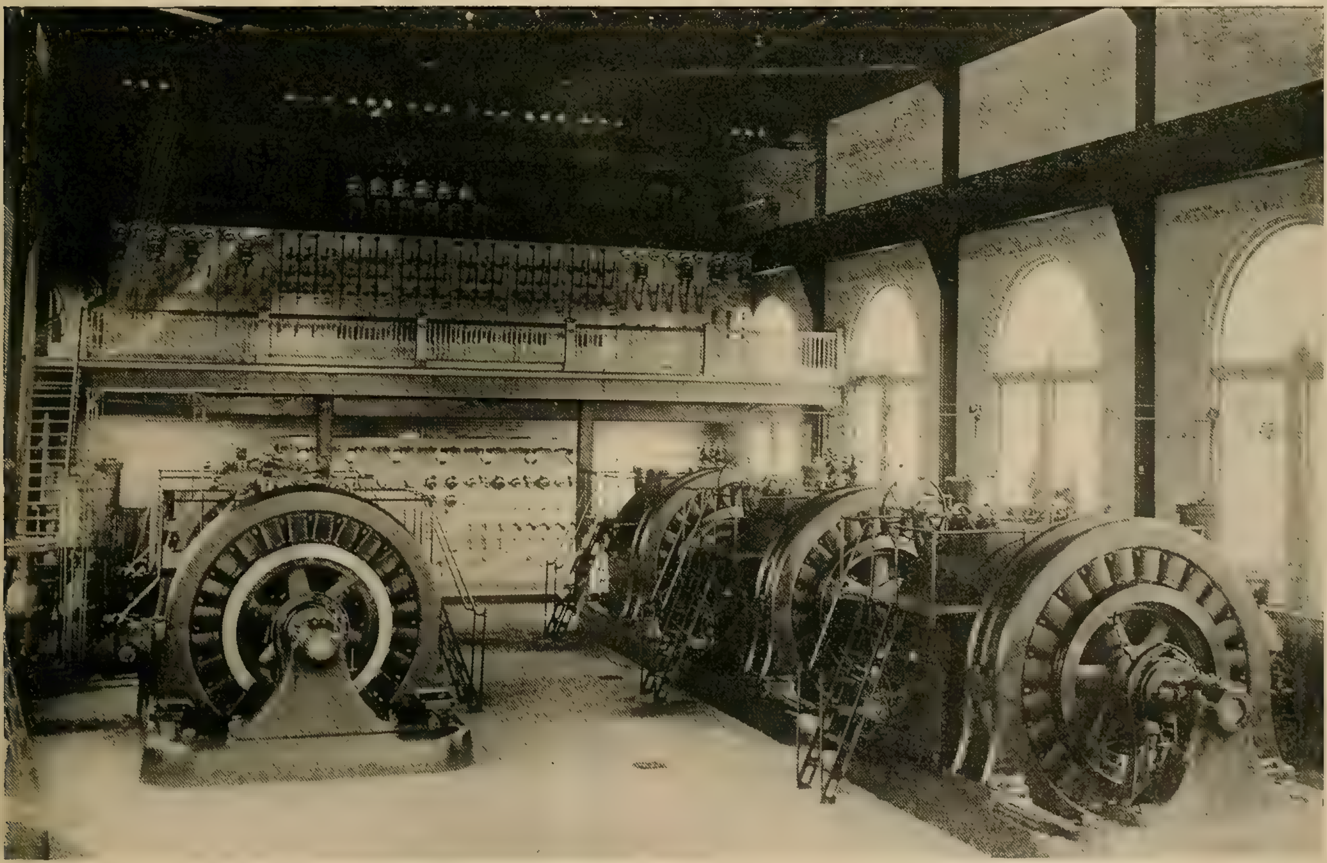
The Journal of Electricity

VOL. V. MARCH, 1898. No. 6

The Pioneer Electric Power Transmission

WITH an annual rainfall that will probably average between twenty-five and thirty inches and a drainage area of about 360 square miles, the river flowing down Ogden Canyon is of such proportion and the topography of its course is of such a character that it affords an abundant water power which has been recognized as of great value for many years. The slope of the stream in the upper valley is comparatively gradual, while in the six miles of the canyon there is a total fall of nearly 500 feet. It is this portion of the river that has for so long been an attractive field for the development of power, but apart from a small saw-mill near its mouth, there have been only abortive attempts made at utilizing the fall of the stream, and none of these earlier plants are now in operation.

Twenty miles or so East of the eastern borders of Great Salt Lake, the Wahsatch mountains rise to an elevation of over 9,000 feet above the sea level, the altitude of the lake itself being about 4,300 feet, and the beautifully snow-capped peaks of the rugged range form one of the many charming features of the Basin of the Great Salt Lake. It is in the Wahsatch mountains that the Ogden river rises, and they are traversed by the canyon of the river. Ogden Canyon is a narrow winding gorge, walled in by precipitous mountains and possessing a grandeur that is surpassed by few other portions of the Rocky mountains. The canyon is only a few hundred feet in width at the bottom all the way between its mouth and a point six miles above, where it broadens out into a noble valley, some eight miles long by four miles wide.



INTERIOR OF THE PIONEER ELECTRIC POWER COMPANY'S POWER HOUSE

The flow of the river varies greatly in different years and at different seasons. In May and June, when the snow on the mountains melts, a maximum flow of 4,800 cu. ft. per second has been measured, while a minimum of 80 cu. ft. in August and September is also on record.

The minimum in average years is fully 125 cu. ft. per second. In 1896 the flow did not go below 175 cu. ft. per second. This refers to the flow of the river-bed near the dam site, but there is also considerable underflow in the gravel.

Within a radius of forty miles of this water power are the flourishing cities of Ogden and Salt Lake City, the industries of which are consuming thousands of horse power, together with many mining enterprises outside of the cities proper. The determination to utilize the water power of Ogden Canyon for the development of power and for irrigation led to the organization of the Pioneer Electric Power Company, of Utah, which has installed and is now operating the interesting transmission plant about to be described. The conception and successful completion of the works are largely due to the efforts of C. K. Bannister, who, as chief engineer and secretary of the company, has devoted several years to the careful study of the engineering and financial problems involved. Preliminary surveys were made in 1894 and 1895, but it was not until the beginning of 1896 that the location of the plant was definitely settled and actual construction begun.

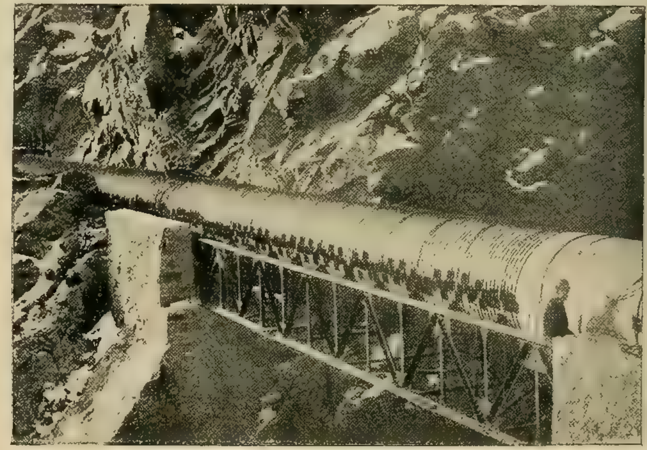
Laying the 6-Foot Wooden Pipe Line

The plans of the Company contemplate the ultimate utilization of the entire flow of the river, to accomplish which to the best advantage will necessitate the construction of a large storage dam and reservoir at the upper end of the canyon, and this storage feature forms the only portion of the system that is not yet completed. At present, a small crib dam with temporary headworks has been built a short distance above the site of the large dam, which gives the necessary head for filling the pipe, but does not provide for any considerable storage of water. A temporary stave pipe, 54 inches in diameter, extends from the crib dam to the 9-ft. tunnel described below. In this way the power plant can be operated and a considerable amount of power generated prior to the construction of the large concrete dam.

The permanent storage reservoir, when completed, will cover an area of about two thousand acres and will have a capacity of nearly fifteen billion gallons. The dam, which will be of concrete masonry founded on the bed rock, will have a length, measured on the crest, of about 400 ft. It will be about 60 ft. high above the present river bed, and the foundation will extend about 40 ft. lower, making a total height of over 100 ft. The sides and bottom of the canyon, at the site of the dam, consist of solid limestone rock, but the bottom is overlaid to a depth of about 40 ft. with coarse gravel containing a large amount of ground-water. A spillway for carrying off the flood waters is to be built on the north side of the canyon.

A 9-ft. tunnel has been excavated through the solid rock around the south abutment of the dam, which, at ordinary stages of the river, will be the sole outlet for the water in the reservoir. It is to connect at its upper end to a masonry inlet-tower, with six 60-in. ports and sluice gates for admitting water. About 100 ft. below the tunnel, and connected to it by a riveted steel pipe 8½ ft. in diameter, the main gatehouse is placed. This building contains two 72-in. valves, one of which serves for discharging surplus water, while the other connects with the main conduit.

The main conduit is a pipe line with an internal diameter of 6 ft. Its total length is 31,600 ft., of which 27,000 ft. consist of wooden stave pipe, while the last 4,600 ft., at the lower end, is riveted steel pipe. It is laid in a trench 8½ ft. wide, and covered with earth to a depth of 3 ft. on top. The wooden pipe is located on the side of the canyon with maximum horizontal curves of 14 deg. and vertical curves of 8 deg., and follows the side of the mountain to a point about half a mile beyond the mouth of the


A Trestle on the Wooden Pipe Line

canyon. The hydraulic grade line is assumed to fall at the rate of 0.2 per feet per 100, and the wooden pipe line is kept close to, but below, a gradient of this slope, which begins at low-water level in the reservoir. The upper portion of the wooden conduit is mainly in earth excavation, but towards the mouth of the canyon the trench was excavated almost entirely in limestone and granite rock.

Along the Wooden Pipe Line

There are eight tunnels in the rock, the longest of which is 667 feet, also eight steel bridges, with a total length of 560 ft., besides a timber trestle. The maximum hydrostatic head on the wooden pipe is 117 ft., giving a pressure of 50 lbs. per square inch.

Steel pipe is used at the lower end of the conduit for pressures exceeding that mentioned above. It extends from the lower end of the wooden pipe to the power house, following an alignment which is straight in plan, but is adapted to the contour of the ground by 14 vertical angles. Between these points the pipe is straight, the elbows being formed with radii of 30 ft. The steel pipe is of 6 ft. diameter until it reaches a point 100 ft. above the power house. Here it divides into two branches, 54 inches in diameter, which lead to two large receivers, one on either side of the power house building.

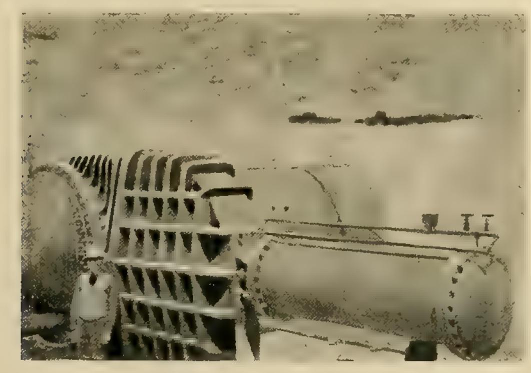
The thickness of the pipe varies from 3-8 to 11-16 ins., and the receivers are made of 7-8-in. plates. All the joints are butt joints, with longitudinal straps on the inside and circumferential straps on the outside. The longitudinal straps are 16 ins. wide and 3-8 sisting of C grade of California asphalt, with the interstices filled with the best quality P. & B. paint. The mixture was melted and kept at a proper temperature by steam coils in the tank. It was found that a prolonged process of coating gave the best results, the coating being smooth and glossy and easily standing the necessary handling without material damage. The pipe line is calculated to deliver 250 cu. ft. per second with a full reservoir, which corresponds to a velocity of flow in the 6-ft. pipe of about 9 ft. per second. Taking the effective head at 440 ft., the gross available horse power will be about 12,500. The total hydrostatic head from the flowline of the reservoir, when it is full, to the center of the receivers, will be 516 ft.

Before proceeding to a description of the power house and electrical equipment, it will be well to note a number of interesting features in connection with the hydraulic equipment that are distinctively original. A number of air, mud, blow-off and relief valves are provided on the pipe line, besides which there are three 72-inch and two 42-inch horizontal gate valves with double gates. In these 72-inch gate valves are two separate stems which are geared together and operated by a hand wheel. As the gates of these valves are very heavy, each gate has two bronze wheels placed on the lower side, preceded and followed by a bronze scraper or track cleaner. These wheels run on a bronze track secured to the case of the valve, and the scraper keeps the tracks clear of mud and other obstructions, and allows the wheels to hug the track closely and prevent the binding of the gates. These valves were designed to withstand a maximum water pressure of about 25 pounds per square inch, and owing to their great weight, they were shipped in sections and put together on the ground.

The third 72-inch valve, which is here illustrated, is placed near an elbow of the steel pipe line, about 100 feet below its junction with the wooden conduit, and the purpose of the gate valve is to permit the closing of the wood pipe so that it can be kept full of water when the steel pipe is empty. The valve was designed for a pressure of 100 lbs. per square inch, the hydrostatic head at this point being nearly 200 feet. The construction of a valve of this size and pressure is almost unprecedented. It is provided with a 12-inch by-pass and is operated by an hydraulic lift supplied with pressure from the main pipe above. The valve measures 8 feet in height and 4 feet from face to face of flanges and its extreme length including the flanges is 24½ feet. The hydraulic lift cylin-

The 6-Foot Steel Pipe Line—Concrete Anchor Blocks at Elbows der is lined with bronze to prevent corrosion, the spindle within it being of steel with a bronze casing 4½ inches in diameter. It has but a single valve stem, which is also of bronze. The total weight of the valve is 52,000 lbs. and twenty four horses were required to move its heaviest piece.

Two relief openings, consisting of an outlet shaft and stand pipe are provided, and these are of a peculiarly novel character. At one of the points where the pipe line runs through a tunnel, the pipe line is a little below the lower hydraulic grade line and about fifty feet below the surface of the ground. This point was determined upon as the location of the outlet shaft, which was sunk from the top of the mountain down vertically to an intersection with the tunnel, fifty feet below. The shaft is six feet in diameter and is through solid rock. With a full reservoir, the top of the water in the shaft comes close to the highest hydraulic grade, and obviously the pressure of water in the pipe line can never exceed that due to the head of water corresponding to top of the shaft. This reduces the static head on the lower part of the pipe line by about fifty feet, and in case the lower gates near the power house are closed the shaft will, of course, overflow until the inlet gates at the dam are closed. A further important function of the shaft is to act as a relief outlet in case of accident to the lower part of the pipe line.



A 72-Inch Gate Valve

This relief shaft is not lined in any way, but connects with the tunnel below through which the water flows as it would through a pipe line. The tunnel and shaft is, as stated, run through solid rock and the wooden pipe is left out of the tunnel for a distance of about 100 feet, the pipes being connected to the tunnel by steel angle rings and flanges similar to those used for joining the steel and wooden pipes, which are imbedded in concrete.

In addition to this shaft a stand-pipe was built which connects with the 6-ft. steel conduit just below its junction with the wooden pipe, and a short distance above the heavy 72-in. valve. This stand-pipe is a wooden stave pipe, 49 ins. in internal diameter, built of 24 staves and banded in the same way as the 6-ft. pipe. It is laid on a tangent and follows the contour of the ground up to the hydrostatic grade line. It is 550 ft. long, and is intended mainly to act as a safety valve in case the large valves below should be too suddenly closed, or in case of a collapse of the pipe.

These two relief openings will always permit the water to rise freely to the levels corresponding to the pressure at the points where they leave the main conduit. As the pipe is of practically constant diameter and of the same construction from the dam to the lower stand pipe, there will be an excellent chance for determining the true coefficient of friction in the wooden pipe for different velocities of flow.

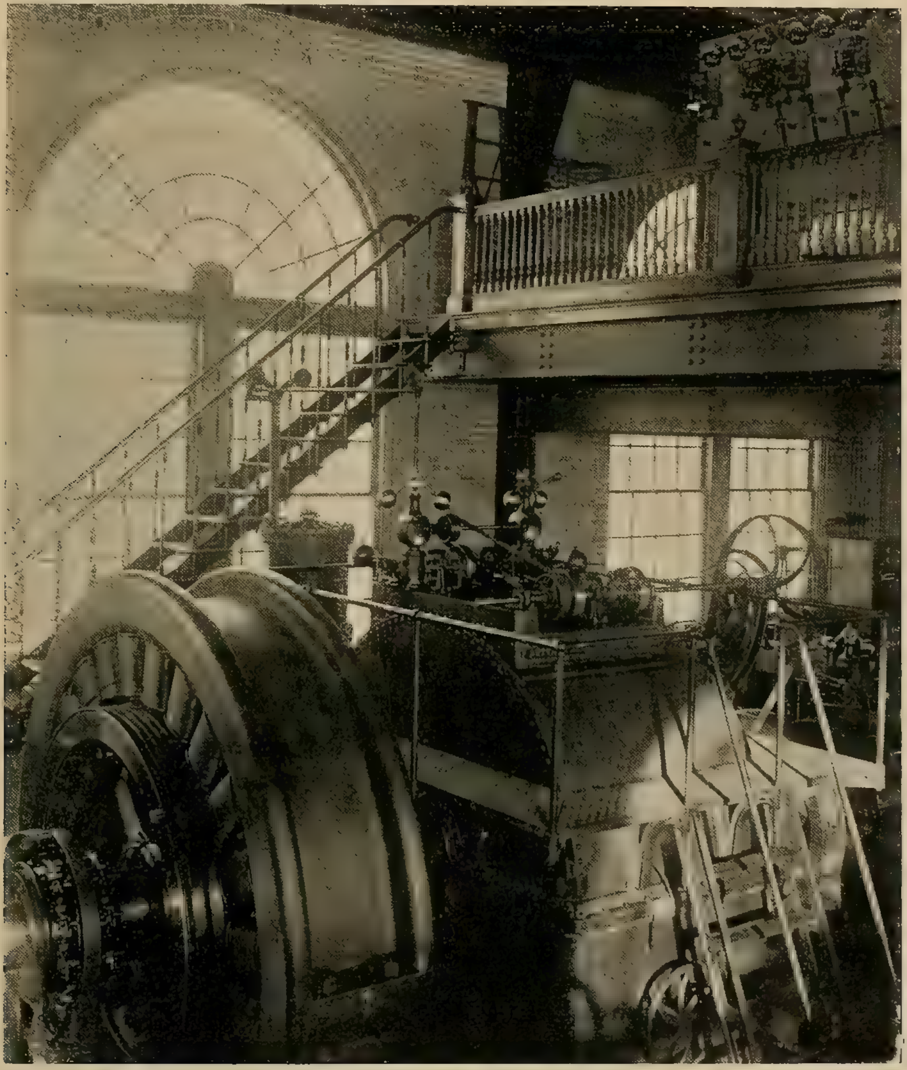
Mr. L. S. Boggs, electrical engineer of the Pioneer Power Company, in describing the remaining interesting features of the hydraulic equipment; states that water is delivered from the pipe conduit into two receivers which are buried one at either side of the power house. These receivers are each six feet in diameter and, in their general appearance and the materials used, closely resemble the regular steel pipe conduit. The thickness of the metal, however, is increased to 7-8-inches in order to allow for water hammer, and besides this, the edges of all plates and straps were planed and the rivit holes were reamed out fully 1-8th of an inch after punching.

The receivers are provided with five safety valves each, which discharge when the pressure exceeds 200 lbs. per square inch, as well as an outlet gate from the bottom. From each of these receivers, five 30-inch and one 10-inch intake pipes extend to the walls of the power house to connect with the water wheel nozzle pipes. Between these intakes and the nozzle pipes are placed the following valves, in order named: One 18-in. geared gate valve, one 18-inch hydraulic gate valve, and one 18-inch butterfly valve.

The 18-inch geared gate valve is only to be used in case of repairs to the particular machine that it governs, and is left open on all other occasions. The 18-inch hydraulic gate valve is piped up to a small D valve, which is placed back of the switchboard and under the floor, and by means of a lever on the switchboard, connected to this D valve, the gate can be opened or closed at the operator's will. This valve is the one which is to be used for starting or stopping a wheel. The 18-inch butterfly valve is operated by means of a worm gear from the governor, and is used in checking the speed of the wheel by reducing the head or pressure near the nozzle, and thus avoiding a sudden fall of head in the main pipe line, which would be detrimental to the proper working of the plant.

The nozzle for the water-wheels has six rectangular openings or ports 1 11-16 x 3 1-2 inches in area. This nozzle is bolted to a tapering cast-iron pipe, securely fastened to the base of the machine, and the ports in the nozzle are made continuous, with a separation between each of them 1-2-inch thick. Sliding back of the ports in this nozzle is a tongue, connected to the piston rods of two hydraulic cylinders which are placed one on each side of the head of the nozzle. These hydraulic cylinders are piped to another D valve, under the floor, back of the switchboard, which is also controlled by a lever on the switchboard. The operator is thus enabled to close one or more of the nozzle ports as he may desire. On the opposite side of the water-wheel from these hydraulic cylinders is a hand-wheel, which is geared to a rack that moves a similar tongue for opening or closing the nozzle ports on its extreme end. The levers that operate the hydraulic gate and nozzle are placed near the top of the switchboard. The set of levers for each water-wheel is placed in the panel governing the generator which is driven by the wheel in question, so that the operations required in starting or stopping these machines are reduced to a minimum.

There is also between these levers an indicator with two hands, one showing the movement of the hydraulic gate and the other that of the nozzle.



Knight Governors in the Pioneer Electric Power Plant

The power house is built of pressed brick, with concrete and rubble footings, and cut-stone trimmings. Its outside dimensions are 135 ft. in length by 50 ft. in width. The roof trusses are of steel, and are supported on steel posts imbedded in the brick walls, the covering consists of standing seam steel roofing laid on a 2-inch sheeting of Douglas fir. A traveling crane of 15 tons capacity, operated by hand power, traverses the building, the track girders being carried by steel posts. This building contains all the hydraulic and electric machinery used. A smaller, separate building serves as a machine and blacksmith shop.

The Knight tangential water wheel, which is made by Messrs. Knight & Company, of Sutter Creek, Cal., and is so well known throughout the Pacific Coast, is used. These wheels are 58 inches in diameter, and have 45 bronze buckets cast in one solid piece; 14 of these will, when the nozzle ports are all open, receive the water at the same instant. The centers of the wheels are made of cast steel, the buckets being pressed on these steel centers, and secured with turned bolts, fitted in reamed holes, passing through both pieces of metal. These wheels were bored to fit, and are keyed to the generator shaft, each wheel being faced and perfectly balanced. They each have a capacity of 1,250 horse power at 300 r. p. m.

Each water-wheel is provided with two fly-wheels, about 70 inches in diameter, each of which weighs about two tons, and is placed inside of a housing on each side of the wheel. These fly-wheels are banded with 3-4 x 5-inch Ulster iron, shrunk on hot. They are split in three parts and are filled with metal, banded, bored to fit, and keyed to the generator shaft. They are turned on the face and nicely balanced. The armature, armature shaft, two fly-wheels and one water-wheel, which comprises the moving parts, weigh 15 tons, which greatly helps in maintaining a uniform speed, notwithstanding changes of head in the main pipe, or changes in the generator load.

The water-wheel, fly-wheel, nozzle and the two hydraulic cylinders are encased in a steel housing, bolted to the machine bed-frame. On the top of this housing is placed the speed-regulating apparatus or governor, as shown in the accompanying illustration, the governor being driven from the water-wheel end of the armature shaft, and is geared to the shaft of the worm gear which operates the butterfly valve already referred to. There is also a hand-lever on the shaft of this butterfly valve that is used in regulating the opening until the governor picks up, as in the starting of a machine. Between the two lines of machines and down through the center of the building underneath the concrete floor is the spillway into which the wheels discharge the water, and through which the water is carried back to the river from which it as taken.

The Knight water wheels are direct connected to the electric generators. The complete plant will consist of ten water-wheels and dynamos, but only five are at present installed, although the power-house building, the receivers, and the machine foundations, have been built in such a way that the whole number of machines can be erected at any time.

The generating set consists of five General Electric three phase alternators, each having an output of 750 kilowatts, at 2300 volts, with a frequency of 60 cycles when running at 300 revolutions. The generators are of the inwardly projecting pole type with revolving armatures, and they are connected with the switchboard through subways which carry lead covered three wire, concentric 250,000 circular mill cables. Two exciters, each having a capacity of 100 kilowatts at 500 volts, are each direct connected to a Knight water wheel running at 550 r. p. m., and the output of either exciter will be sufficient to carry the ten generators which it is proposed to ultimately install. The exciter wheels are cross connected to each receiver so that either exciter may be run from either receiver.

Across one end of the main floor of the power house is placed the generator switchboard, consisting of seven marble panels. Five of these panels are for the generators, one is for the exciters and the remaining one is for the usual instruments. Each generator panel is fitted with one alternating voltmeter, one ammeter and one wattmeter, with appropriate switches. At the top of the panel as shown in the accompanying view, may be seen two layers, one of which controls the main gate and the other the nozzle ports. A dial with two handles indicates the position of the main gate and the number of ports open. The instrument panel is fitted with pilot lamp, total load wattmeters, recording voltmeters and a water pressure gauge, as well as one synchronizer and one ground detector. The panels are 90 inches high by 36 inches wide and two sets of three phase bus bars extend the whole length of the switchboard. One of the interesting features of the equipment consists of a small synchronous motor direct connected to a tachometer, which serves as a speed indicating device.

In the gallery above the generator switchboard is the distributing or line switchboard, which is divided into two sections, one for the primary and the other for the secondary leads. Each section has six panels, and the gallery switchboard, which is built of blue Vermont marble, is 39 feet long. Back of this switchboard, on a raised platform, are placed nine 250 kilowatt single-phase step-up transformers, with both primary and secondary circuits connected in delta. These take current from the generators at 2,300 volts and deliver it to line at 16,100 volts. The Ogden circuits are supplied direct from the generators at 2,300 volts, as Ogden is but two miles distant. The long distance circuits, however, extend to Salt Lake City, the distance by pole line being 36½ miles. The current reaches the sub-station at Salt Lake City, at a potential of 13,800 volts, which it reduces to 2,300 volts for local distribution. The raising transformers at the power house are ventilated by air blasts supplied from two blowers, each of which is direct connected to a 2½ h. p. 500-volt direct current motor.

The transmission line consists of two independent pole lines of three wires each, the wires being of No. 1, B. & S. gauge, spiralled every mile. At the voltage used, the line will carry 3,000 h. p. with a loss of ten per cent, but it is the intention to change the transformer connections from delta to star, which will increase the voltage to in the neighborhood of 28,000 volts and, in so doing, the capacity of the line will be quadrupled. The feasibility of so doing, as well as of the transmission over a 73-mile circuit, has been demonstrated by actual experiment over the Pioneer lines, as has been described in the Journal heretofore.

From the sub-station in Salt Lake City are run two circuits for the local distribution and two for the transmission lines, and the switchboards are so arranged that any generator and any set of transformers can be thrown at will on either one or other of these circuits. Thus one circuit can be used for lighting and the other for street railways and power, in which the regulation is not so important. Every precaution has been taken against interruption in the transmission line, and this will probably be duplicated before long. The lines are thoroughly protected by lightning arresters.

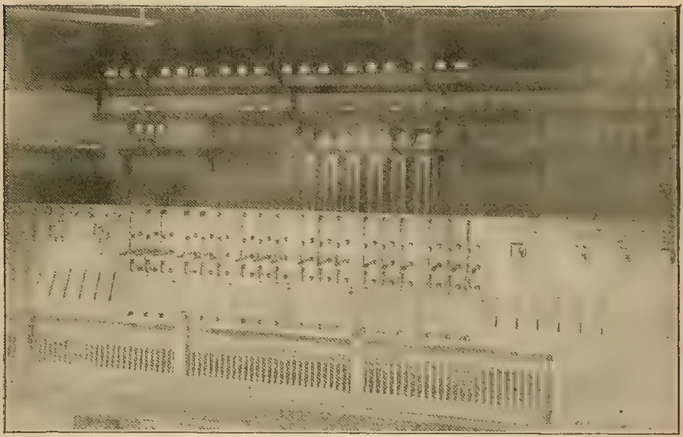
The work was carried out under the direction of C. K. Bannister as chief engineer, while Messrs. Willard Young and H. M. McCartney successively held the position of assistant chief engineer. Mr. L. S. Boggs is the company's electrical engineer, while Mr. R. F. Hayward was consulting engineer for the hydraulic and electric equipment, and George H. Pegram acted in an advisory capacity as consulting engineer.

FOUR FEATURES OF THE PIONEER PLANT

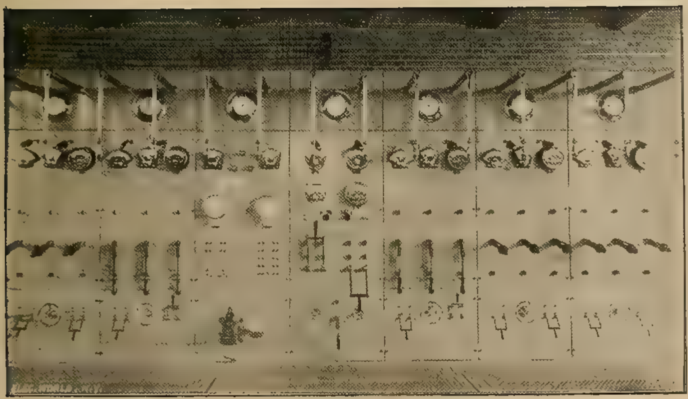
Supplement to the Journal of Electricity

Vol. V, No. 6, March, 1898

The Shaft Relief During Overflow



The High Tension Switchboard



The Generator Switchboard

A Characteristic View in Ogden Canyon

Transmission

PROPERTIES OF HIGH POTENTIAL INSULATORS.

By Albert T. Bell.

I HAVE read the recent article in the Journal of Electricity, entitled "Insulators for Transmission Lines," and the articles in the January number entitled "A Multiglaze Insulator" and "The Making of Porcelain Insulators." The articles are all of great interest to those who have had experience with the difficulties of insulation on long distance transmission lines, but they are rather surprising in one respect, namely, that they all indicate a belief on the part of the writers that no "successful" insulator has yet been found and used in the Pacific Coast market. This is particularly so as there has been no trouble with insulators on the part of the Eastern companies at Niagara Falls, Chambly or Lachine, in all of which localities the climate conditions are supposed to be much more severe than those existing on the Pacific Coast.

In the first mentioned article I notice a statement that a glass insulator is better than a porcelain insulator in that "it will not puncture". The experiments which have been made in testing glass and porcelain insulators at voltages of 40,000 and upward indicate that while it is not feasible to puncture a small glass insulator yet the reason for the failure to puncture it is not so much because of its "puncture resisting qualities" as it is because the glass avoids the puncture test by permitting and assisting the current to go around rather than through it. Porcelain, on the other hand, meets the test squarely, and is either punctured by the current or holds it surely, not allowing it to pass around the surface readily.

I notice the further statement of the superiority of glass in that defects existing in it "are readily discernible with the eye". Experience again with high voltage testing of both glass and porcelain indicates that tests with the eye are of value only as against mechanical defects, and that nothing less than a very high voltage "break down test" with salt water and a transformer of great strength and pressure will determine the electrical resistance of an insulator.

It is further stated, that "by the proper annealing of glass the objection of extreme brittleness is removed." It is a well-known fact that the additional strength which is imparted to glass by annealing lies in some peculiar manner on the surface only and that it pertains exclusively to the object so annealed as a whole and not to its individual molecules. In other words, annealing is what might be called a centripetal force or protection, and further when any part of the object is broken, this strength and protection departs at once from the remaining portion of the object. In the case of insulators, as is well known by telegraph linemen, a glass insulator when struck by shot or stone "flies" and allows the conductor to fall to the cross-arm. The experience of the same men with porcelain insulators is, that in the first place, shot will not break a porcelain insulator and further that when struck by a stone or heavy missle only that part of the insulator which is in immediate contact is broken and the remained of it stays on the pin and holds up the conductor, showing that the strength of the porcelain is evenly distributed throughout its whole body.

It is also stated in the article in question, that "the difference between the hygroscopic properties of porcelain and glass cannot be measured; and there seems to be good ground for this assertion." It is not clear whether the writer means that the hygroscopic difference is so great or of such a nature that no means have been devised for measuring it, or whether, on the other hand, he intends to convey the impression that there is no hygroscopic difference. The fact of the case, however, is, that the hygroscopic difference is very great and very material. Laboratory and working tests by electricians in the East have conclusively determined that there was such a difference, some of the tests being over parallel lines of glass and porcelain approximately one hundred miles long; the most conclusive and absolute proof, however, is the fact that porcelain insulators are in exclusive use in England and other foreign countries by reason of the failure of glass to satisfactorily insulate their lines in the almost continuous moist and foggy condition of the atmosphere.

The reasons which are given in favor of "a multi-glaze insulator" appear to indicate the cause of the trouble which transmission lines on the Pacific Coast have had with insulators. The assertion that "the puncture resisting properties of a porcelain insulator for use on high potential lines depends largely, if not entirely, upon the quality of the glaze with which it is covered and the thoroughness with which it is applied" is certainly based on a misapprehension. Table-ware potters are well acquainted with the fact that glaze is absorbent to a certain degree and that it is only a question of time and proper exposure when it will allow itself to be penetrated by acids, alkalies or moisture. So well recognized is this fact that the best class of table ware is made from a porcelain body which in itself and without any reference to the glaze is absolutely and entirely acid, alkali and moisture proof. In other words, the glaze is the weakest part of a good piece of table china.

In the "multi-glaze" insulator there are "six skins of glaze and two layers of glass." An experienced table-ware manufacturer would at once say that there were four times as many chances of trouble with such an insulator as with one having only the inner and outer coat of glaze to protect it from dirt and to give it its hygroscopic qualities.

The claim that "should the outer shell absorb moisture the two layers of glass, together with the remaining five layers of glaze, will unfailingly prevent the passage of current * * * or moisture * * * beyond the outer shell" is a confession of the weakness of the glaze and that the manufacturers put no dependence on it.

Insulators of this style have ben tested at a high voltage and found to stand a good pressure, but after having their outer petticoats broken and being soaked in salt water, they have failed utterly to withstand the same test; whereas one piece insulators made of a superior quality of porcelain have undergone a parallel test at the same time and stood up just as well after the breakage and soaking as before. This fact is of great importance in view of the necessity of having insulators that can be depended on in long stretches of wet or foggy weather, and also to support the wire and insulate, even though damaged by stones thrown by small boys or rifle balls shot by gunners.

In thus advocating and presenting the advantages of a porcelain insulator I fully agree with Dr. Perrine's statement that "only that amount of glass should be present which is necessary to fill up the porosity of the rehydrated silicate of alumina" for the introduction of any greater amount of glass than this will at once give to the porcelain that brittleness which is the charasteristic and one of the chief disadvantages of glass. The temptation to do this is very great. A reference again to the condition of the table-ware trade will show that it is a very common thing for manufacturers of cheap goods to use the glassy pastes. The difference, however, is well recognized in the trade, and a broad distinction is made in price between the true porcelain of Limoges and the glassy product of Carlsbad. The differences between the bodies can be detected practically by simple tests of shock as well as by a visual comparison of the fractures of the two grades of ware.

I must take exception, however, to his statement that "it is at present unnecessary to attempt any re-designing of the insulators in use until we have thoroughly tested the capabilities of our porcelain manufacturers to produce insulators of the present form strong enough to carry the wire and sufficiently solid to prevent the escape of electricity through the body of the porcelain without reference to the character or existence of the glazing."

All the insulators made of the best grade of insulator porcelain are tested electrically before they are glazed in order to determine the existence of any cracks or flaws in the body itself. They are then glazed and re-tested in order to determine whether they have met with any accident in the subsequent handling or the second fire in the glost kiln. An insulator which passes these tests of from 25,000 to 100,000 volts according to its size, can be depended on for service.

The cracking in the body of many of the insulators which have been on the market, and the porosity as well, have been due to the use of formulas which were not calculated to produce a satisfactory article, to carelessness in the process of manufacture, to difficulty of moulding, and to the inability of the moulded insulators to withstand or the failure of the manufacturer to give them the proper heat.

In substantiation of my assertion that insulators have been made capable of doing the work, I need only to refer to the previously published letter of Mr. Paul M. Lincoln, Electrical Superintendent of the Niagara Falls Power Co., dated February 4th, 1898, which was written soon after the recent heavy storm which so interrupted travel and electrical communication in the East. The lines therein referred to are approximately 26 miles long and are transmitting about 3500 horse power over six 350,000 c. m. cables at about 11,000 volts.

The recent test for three days of the Pioneer Electric Power Company's lines, as described in the editorial columns of the November, 1897, Journal of Electricity, indicated that they had used one-part porcelain insulator, which fact has since been established by correspondence with Mr. F. O. Blackwell, who conducted the test.

Surely little more can be asked from the porcelain manufacturer who is able to supply insulators which will stand such tests as these. We must therefore look for further improvement in insulation to come from the adoption of improved mechanical and electrical forms. Many people are considering such matters very carefully, and the experience of the last two or three years with high voltage transmission ought to afford a basis for determining what changes can be made to advantage. The principal trouble at present seems to be in connection with the pin, and I hope to see that weak feature eliminated from the best construction within a short time.

PROGRESS OF THE NIAGARA-BUFFALO TRANSMISSION.

Within six months the city of Buffalo will be lighted by electricity generated at Niagara Falls and received in a large new power house at Buffalo. The plant will be one of the best examples of modern electrical practice, under conditions which differ greatly from those which have hitherto prevailed. At present the lighting of Buffalo is effected by the Buffalo General Electric Company, which supplies current for the arc lights and incandescent lamps from dynamos driven by steam engines, and also furnishes a certain amount of current for motors. In the new station steam will have no place. What work cannot be done by electricity direct from the Falls will, themselves, be driven by Niagara power. All of the apparatus without exception, at present ordered for this new power house will be manufactured by the General Electric Company.

The first contact made with the Cataract Power and Conduit Company, covers eleven 250 air blast transformers wound for 1,100 or 22,000 volts primary and stepping down to 352 volts secondary. They will be fed by two independent sets of cables, so that the light and power service may not be interrupted in case of a breakdown of one. In this contract are included the motors and blowers necessary to keep a current of cold air constantly circulating through the transformers and a completed switchboard equipment for connecting them to the high voltage line and to the secondary circuits. From these transformers the current will be delivered to the bus bars of the Buffalo General Electric Company.

The current from the Falls having a periodicity of 25 cycles, it has been found expedient to raise this to 60 cycles in order that the incandescent lights may be operated without perceptible flicker. Frequency changers or motor generators will be employed, each of 400 kw. capacity.

The current for the arc lighting in the streets will be generated by thirty No. 12, 125 light Brush arc machines; these machines will be set one on each side of a 250 h. p. synchronous motor, to which they will be directly coupled.

The low tension direct current for small mercantile and domestic power purposes, such as running elevators, driving printing presses, machinery, etc., will be obtained from two rotary converters, each of 200 h. p. capacity. These are of the same type as those installed by the General Electric Company, in the Niagara Street Power House of the Buffalo Railway Company, and will deliver the current at 500 volts.

The total capacity of the plant will be about 5,900 h. p. Thirty arc light dynamos will furnish current for 3,750 arc lamps; the incandescent lights will number about 24,000 and the estimated number of small motors is 600. The company now lights 2,000 arc lamps on the East side and 862 on the West, and the arc light capacity of the plant will shortly be increased.

The Power House will be so laid out that under a single roof there will be space for three times the amount of apparatus ordered up to the present time. The installation will be unique in that it will be the only plant in the world of this size which will depend upon an outside source of generation for the current which it uses. The layout will be complete and perfect from every point of view, especially from that of the distribution of the largest amount of power with the least space occupied and the minimum of labor and attendance.

Telegraphy

WIRELESS TELEGRAPHY AT THE OMAHA EXPOSITION.

Telegraphing at sea without wires will be practically demonstrated at the coming Trans-Mississippi Exposition at Omaha, by means of the apparatus of young Guzlielmo Marconi, the Italian electrician, who claims to be the inventor of the wireless telegraphy. The singular feature of this method of telegraphing is shown by a wire extending vertically in the air, connected to a radiator on the ground. Messages without wires have been sent a distance of twelve miles to a ship at sea. By simply increasing the height of the vertical wire the influence of the machine can be extended over a distance augmenting in geometrical ratio to the increased height of the wire.

Electro-Therapeuty

A LARGE ELECTRO-MAGNET FOR OCULISTS' USE.

By Philip Mills Jones, M. D.

THE fact that the vast majority of all particles of metal that accidentally penetrate the eye-ball, are of iron or steel, led surgeons to believe that the well known magnetic properties of these metals might be made use of in efforts to remove them from the eye. It is certainly a rational train of reasoning that would lead to the use of a magnet in the treatment of such cases, but so far as I can ascertain, it has only been employed for a comparatively few years.

McKeown was, I believe, the first to use the magnet for the removal of foreign bodies of magnetic matter from the eye, and if I am not much mistaken, he employed a permanent magnet for this purpose.

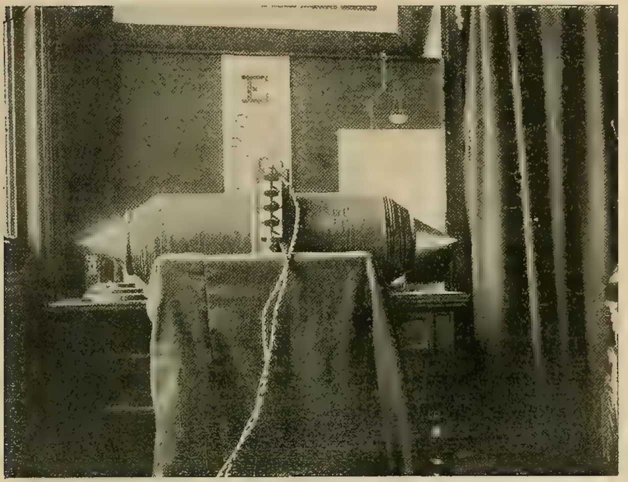
The magnet in the hands of Hirschberg, a most skillful operator, took the form of a compact electro-magnet, and has since been called by his name—the Hirschberg magnet. The instrument is described by Prof. Fuchs, in his well known work on diseases of the eye, as follows: "About a rod of soft iron is wound a spiral coil of copper wire, not too thin, the two ends of which are connected with a powerful galvanic element. The ends of the iron rod, which project somewhat beyond the spiral, are a little bent and end in a blunt point, adapted for introduction into the interior of the eye. For this latter purpose we enter through the wound itself, in case this is large enough, or we make an incision in a suitable situation."

But no matter how skilful the surgeon, there must necessarily be a good deal of damage done to the contents of the eye-ball because of the twisting and turning of the magnet within the eye, in the search for the particle of foreign matter. The surgeon may know with absolute certainty that there is a particle of magnetic matter within the eye, but he cannot tell exactly its location. He must, therefore, unless the foreign body is found at once upon the introduction of the tip of the magnet, as is very seldom the case, move the instrument around more or less in order to attract the small particle, for the field of force of any electro-magnet sufficiently small to be readily handled, must of necessity be very small. This manipulation of the magnet within the eye-ball has a very unpleasant effect upon the "vitrious humor," as the viscid fluid filling the interior of the eye is called.

Though the results which followed the use of Hirchberg's magnet were better than had customarily been secured before its use, still the eye that had been penetrated by a piece of iron or steel was in the majority of cases looked upon with much anxiety by the eye surgeon. For though he might, and in all probability would, eventually remove the piece of metal by means of the Hirschberg magnet, still there was always to be remembered the fact that he would, perhaps, stir up the vitrious humor so thoroughly as to produce a very unpleasant inflammation, perhaps even resulting in the loss of the eye.

Prof. Habb of Zurich, a well known oculist of Europe, conceived an entirely new scheme for dealing with these very troublesome cases; and whereas the Hirschberg magnet was operated on the assumption that it was necessary to bring the magnet actually within the eye, Habb realized that all that was necessary was to have a sufficiently strong magnetic field, which might just as well be projected from a magnet that was entirely without the eye. He therefore called in the assistance of Prof. Kleiner of the High School of Zurich, and had a large magnet constructed, that would fulfill the desired conditons. This magnet he described at some length in the "Transactions of the Ophthalmological Society of Heidelberg." There are several of these magnets in this country, and one in San Francisco.

Habbs' description of the magnet is as follows: The core, of soft iron, is 10 cm., in diameter; the length, 66 cm.; weight, 30 kg.; the ends being beveled to an angle of about 65 deg. The point at either end is made detachable and is gold plated, so that it may be removed and sterilized.. The winding is made in two sections, fitted about the core. These spools are placed 7 cm. apart at the center, and are wound with insulated copper wire 2 mm. in diameter (about No. 12 B. & S.), to a thickness of 23 cm. As the winding progresses, about three turns are dropped at the outer end, thus giving the spool a beveled appearance. The magnet is mounted on a brass pivot head, so that it may be rotated, and this again is mounted on a heavy wooden stand. The resistance is not given, nor is the amount of wire used stated; but the statement is made that the magnet uses a current of 50 to 60 volts, and from 6 to 8 amperes. It is further stated that it will carry a current of 20 to 30 amperes for a short time.



A Large Electro-Magnet for Oculists' Use

The number of lines of force in the field is not given, nor is the strength very accurately described. All that is said of the strength is that the attraction for one gram of iron (the shape of the piece of this is not given, which will make a difference of at least 50 per cent) placed 5 mm. from the point of the magnet with a current of 5.6 amperes passing is 113 grams; with 7.9 amperes, it is 213 grams; at a distance of 10 mm., and with 5.4 amperes, it is 24 grams; at the same distance, but with 8.2 amperes, it is 63 grams, and with 10 amperes, it is 93 grams.

Some time ago I was asked by Dr. Kaspar Pischl, of San Francisco, to design for him a magnet that would have a greater range, in other words, it was to be so made as to give the same force or pull as the Habb magnet, or if desired a still greater pull. The description of the Habb magnet given above (and, by the way, the above data are not from Habb's original paper, but from a recent translation of it) was not at that time available, nor could I make any very careful examination of the Habb magnet that is owned in San Francisco. The task was therefore not so simple as it at present may seem.

I finally worked out what I thought would give about the conditions required, and had the magnet made by Mr. A. E. Kraeger, of 126 Kearney street, San Francisco. Owing to the lack of accurate data, the work was somewhat experimental, but the result was everything that I had desired.

The general shape of the magnet is somewhat the same as the Habb magnet, the difference being that the present one is longer, is smaller in diameter, and is a little heavier; but as the magnet could in no possible case be portable, the extra weight is of no consequence. The core is of the best grade of soft Norway iron, 81 cm. in length and turned down to a diameter of 10 cm. The cone-shaped ends are beveled to a slightly more acute angle, to correspond to the beveled ends of the spools of wire. The extreme end of the cone, for about three or four cm. is made detachable, as in the Habb magnet in order that the part coming into actual contact with the eye, may be sterilized when desired.

These detachable tips are also gold plated. About the core a covering of good insulating material is wrapped and on top of this the wire is wound.

The wire used was No. 12 B. & S., single cotton covered copper. The single covered wire was chosen deliberately because it takes up less space and allows the wire to come nearer the core. One hundred and sixty pounds of wire were used, divided equally between the two sides, and no additional insulation other than that on the iron core was emloyed. When wound full the spools have a diameter of eight inches. The four terminals are brought up and connected to the blocks of a switching or commutating device, placed on the side of the collar that fills the central space between the two sections or spools, in a manner that can be readily understood by a glance at the half-tone illustration which accompanies this article. The ends of the wires are made fast, each one to a block of brass on the block switchboard shown and the connections are so arranged that the two sections may be connected in series, having a resistance of 32 ohms; in multiple, with a resistance of 8 ohms, or either may be used separately if desired, in this case the resistance being about 16 ohms. It is intended to be connected to the 115-volt direct current circuit, and when so connected, with the two sections joined in multiple, it passes about 14.5 amperes.

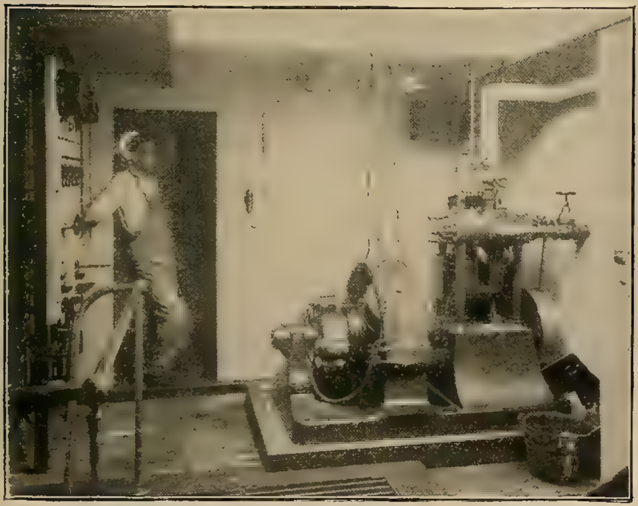
Dr. Pischl has made some very careful tests of the pulling strength of this magnet, and finds that it is almost exactly double that of the magnet described by Habb; the strength of the Habb magnet, with both sections connected in multiple, is just about the same as this magnet, with but one section connected; and when both sections of the magnet made by Mr. Kraeger are connected in multiple, it has exactly double the pull of the magnet described as Habb's. Of course there is nothing startling in the construction of a large magnet—the only feature of interest is the fact that the work was largely empirical, but it turned out to be a pretty good guess.

Illumination

ELECTRICITY ON A LIGHTSHIP.

Light-ship No. 69 has now been anchored on the dangerous Diamond Shoal, off Cape Hatteras, in 30 fathoms for three months, and having ridden through the gales that prevail off that perilous spot on the Atlantic in entire safety during the roughest weather, has proved to the satisfaction of the Lighthouse Board that a light vessel can safely be maintained there. The captains have now become familiar with the light, and until the ship is replaced by a lighthouse as originally intended, she will be a beacon to be carefully watched for and avoided.

Nos. 68 and 69 are sister steamships, built at the yards of the Bath Iron Works, at Bath, Me.; No. 68 is the light-ship off Fire Island. Both 68 and 69 are unusually powerful composite vessels, 122 ft. 10 in. long over all, 29 ft. 6 inches extreme beam, and 22 ft. moulded depth. They are provided with propelling machinery to enable them to steam to their stations, and, also in case of necessity, to steam away from their dangerous positions. The engines are of the simple condensing vertical type, with a cylinder 20 in. in diameter and 22 in. stroke, developing 350 h. p. at 150 revolutions. Steam is furnished at 100 lbs. pressure by a steel Scotch boiler 12 ft. 2 in. in diameter and 11 ft. long. Two vertical donkey boilers furnish steam for the electric lighting plant, windlass, pumps, fog signals, and for boating. The vessels are also fitted with steam steering gear, bells, a steam winch and full equipment of anchors and chain cables. The two masts are of steel; each exclusive of the flag poles, 64½ ft. high. The electric lights are suspended at the mast heads and are surrounded by a gallery for day signals.



The Dynamo Room of a Lightship

The Diamond Shoal Lightship

To avoid chance of breakdown, the electric plant on each vessel is in duplicate. Each plant consists of two marine generating sets with dynamo and engine both built by the General Electric Company. The four-pole dynamos are 8 kilowatt 350 revolution machines, directly connected to 4½ in. x 4 in. double cylinder engines. The switchboards are of Vermont marble, and the wiring appliances used throughout are of the type approved by the U. S. Naval Board of Inspection. The dynamos furnish 100 volt current to eight 100 candle power lamps —four at each masthead and forty 16 candle-power lamps—throughout the vessel. The masthead lights are each enclosed in a lens lantern, three being used and the fourth held in reserve. Connected in circuit to the masthead lights is a device making and breaking the circuit and lighting and extinguishing the lamps at regular intervals. A fixed white light shows for twelve seconds and is followed by an eclipse of three seconds. The focal plane of the lights is 57 ft. above the sea, and they will be visible 13 nautical miles away in clear weather. Great reliance is placed upon the electric plants and in their construction more than ordinary care has been taken, on account of possible consequences of a breakdown through accident.

We are indebted to the courtesy of the New York Tribune for the photographs from which the illustrations were made.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity, Gas and Power.

OFFICIAL ORGAN OF THE PACIFIC COAST
ELECTRIC TRANSMISSION ASSOCIATION.

Subscription Payable in Advance. Terms—Domestic, One Dollar
per Year; Foreign, Two Dollars per Year.
Rates for Advertising on Application.

The trade supplied by the San Francisco News Company.

EDITED AND PUBLISHED BY GEO. P. LOW.

Business Office, 22 CLAY STREET
Telephone, Steiner 623.

Address all communications to
Editorial Rooms, 427 TENTH AVE

SAN FRANCISCO, CAL.

Entered as Second-class Matter at the San Francisco Postoffice

Volume V. MARCH, 1898. Number 6

EDITORIAL.

ARE NEWS NOTES WANTED?

A prominent feature of the Journal of Electricity during the first two years of its existence were the department news notes through which, under the headings of "Litigation," "Communication," "Transportation," "Transmission," "Illumination," and "Miscellaneous," were given in concise, succinct, firm information concerning projected enterprises or reports upon the progress being made on works that were under construction. Similarly, the depatment termed "The Lay Press" reproduced the utterances of local papers upon matters of engineering concern and presumed to be of interest to the readers of the Journal.

These features were dispensed with through the belief that the matter there presented was of interest more especially to advertisers than to the great bulk of technical readers, among whom the widest possible circulation is desired, hence it was deemed advisable to devote the space occupied by "News Notes," and "The Lay Press" to matter that bore a technical or scientific, rather than a news imprint. Of late, howeer, several requests have ben made that the publication of news notes should be resumed.

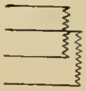
In this, the Journal desires to be guided by the prevailing wishes of its readers, hence an individual expression of opinion upon this matter, which may be submitted by postal or otherwise, is earnestly solicited from each and every reader.

STANDARD ELECTRICAL DIAGRAMS.

The recommendation of the Chicago Electrical Association, as set forth in the report of its committee on standard diagrams, is of such great merit that there is no doubt but that the diagrams suggested will be accepted as standard in engineering practices without further action or endorsement on the part of other organizations. The diagrams possess simplicity itself and the observer of them, whether student or engineer, experiences no difficulty in interpreting their significance at a glance.

The diagrams are mainly of an elementary or fundamental character, and the exercise of very little ingenuity in the combination of the elements there given will enable the giving of graphic expression to almost any electrical device or combination of devices that may arise. Among the diagrams given may be noted characterizations for direct current generators and motors; for alternators; for series, shunt and compound wound dynamos and motors; for delta and star connections for three phase machines; for motor generators; for primary and secondary batteries; for magnetos, telephone hooks, head and hand receivers, transmitters, ordinary and self-restoring annunciator drops and ringing keys, with several other telephone appliances, together with many other most useful drawings of a general nature. These drawings have appeared so generally in the electrical press of late that their reproduction is deemed unnecessary.

The only suggestion that could be offered toward improving the diagrams, would seem to be in the direction of expanding them in the line of polyphase applications. The single phase alternator, for instance, is represented as two concentric circles, each having a tangent line for a collector brush. It might have been well to have foreseen and have curbed the artistic proclivities of the draughtsman, which sometimes runs riot, to the equally simple representations about to be suggested. As a circle has been adopted as symbolic of either generator or motor according to whether the letter "G" or "M" appear within it, consistency to the worthy ideas advanced would have been attained by enclosing the drawings for delta and star windings in circles, if representing dynamo-electric machines, leaving them without circles to represent transformer connections. If the matter of winding is of no immediate consequence, a three-phase generator or motor, would be comprehensively described according to the ideas of the Association, by three concentric circles, each having a tangent line, but such a diagram does not appear in the drawing accompanying the report of the committee. Again, no diagram is given of two-phase work, which leads to the suggestion that two-phase transformers be designated thus:



while placing the above diagram within a circle would represent a two-phase generator or motor with independent windings. An alternative to the latter suggestion is found in the use of a diagram consisting of four concentric circles, each having a tangent line for a collector brush. None of these suggestions detract from the simplicity of the drawings referred to. Great credit is due the members of this committee for their painstaking efforts and the reward of their labors will doubtless be found in the realization that their report will find quick recognition as suggesting the drawings that will be universally adopted as standard.

PROOF POSITIVE OF A GREAT CIRCULATION.

The love of notoriety is such a ruling passion in the breasts of so many half-baked specimens of the genus homo that it should not be considered marvelous to learn that the same trait is to be found in even lower animals. Publicity of criminal achievements incites further crime (and suicide is crime) so, when a great stork learned through these columns that two eagles had won world-wide celebrity by alighting on the 10,000-volt transmission line of the Fresno plant, it promptly greened with envy at the glorified though posthumous notoriety they had achieved and, acting upon a determination to pale their distinction, it gritted its teeth—this bird had teeth, for all the post-mortem examination showed to the contrary—and straddled two live line wires of the Sacramento transmission. There was no hitch in the proceedings and it promptly started on the journey to meet its Fresno prototypes, its exit from this life into the next being accompanied by such lurid, greenish flamings, and such pungent, bluish smoke, suspiciously savored of scorched meat and feathers, as to indicate that the entrance to stork heaven does not portend it to be an Eden of perpetual marsh land, spring time, and plenty.

Wonders never cease, nor does astonishment end with the knowledge that a Sacramento county stork monkey-saw-as-monkey-did its way to eternity by the electric limited line, just because two eagles had done the same thing before in Fresno county and, in so doing, had won much coveted fame. This occurred during the week after the appearance of the Journal of Electricity containing the illustration of the relics of the Fresno eagles, and stranger still to relate, a day or two thereafter, two little owls became imbued with a similar ambition to that which had lured the stork to its death, and their unquenchable thirst for journalistic notoriety so blinded their better judgments that together they grabbed the 10,000-volt lines of the Bakersfield transmission. A flash, a sizz, a puff of scent alone did tell where the owl-lets went.

Now, in the face of these tragic events, who has the hardihood to doubt the influence of the Journal or to question the fact that information contained therein reaches unheard-of-quarters, even to the birds of the air, yea, perhaps to the fish of the sea? True, three of the feathered tribe have evidently read it and died, but generosity suggests that this mortality be accepted as mere coincidence and not as proof of any deadliness of its literary productions. Rather let it stand as evidence of the fact that the Journal reaches every quarter.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

THE WANING OF THE WELSBACH.

Favorable reports are received from different manufacturers and illuminating companies of the waning popularity of the Welsbach burner, and as proved by the accounts of the illuminating companies in whose territories the mantle burner at first made some headway. Any customers which were lost are returning to the incandescent lamp, tired of the expense involved in renewing shattered mantles, and worn out with the ghastliness of the light. Additional proof is furnished by the production and sales reports of the different manufacturing companies, which show a constantly increasing demand for incandescent lamps; as well as for arc lamps, especially those of the enclosed arc type. In stores, restaurants, cafes, hotels and halls where the Welsbach burner secured temporary success, the enclosed arc lamp is rapidly bringing back the use of electricity, while in new establishments the Welsbach burner is not finding much foothold.

AN EXCEPTIONALLY EXCELLENT EDITION.

California's Golden Jubilee (January 24, 1898), brought out several very meritorious special editions of regular publications, one of the very best of which was that of the "Mountain Democrat," of Placerville, Cal., which was a souvenir edition indeed. Typographically, it was the equal of such superb publications as that of "The Ladies' Home Journal;" which it strongly resembled in more ways than in the mere matter of size; its contributed matter was of also unsurpassed excellence and every article bore unmistakable evidences of genius. The story of the discovery of gold by Marshall was told in a clear, entertaining way and with it was related the history of Marshall's life and of the development of the mining industries of El Dorado county. Contrary to the customary procedure, the edition referred to the resources of its own locality as matters of secondary importance, and so gradually and insidiously was the subject of the resources and persons of El Dorado county broached, that the foreign reader, who ordinarily finds nothing of interest in such things, can not bring himself to skip those pages for fear of missing something good. The whole issue was brought out by the regular staff and plant of the "Mountain Democrat," at Placerville, and the sincerest compliment that a fellow publisher can pay to the superb edition is to state that it is to be carefully preserved for the valuable facts it contains and for the most excellent suggestions that can be found therein in the matter of typographical style.

ELECTRIC POWER IN LARGE UNITS.

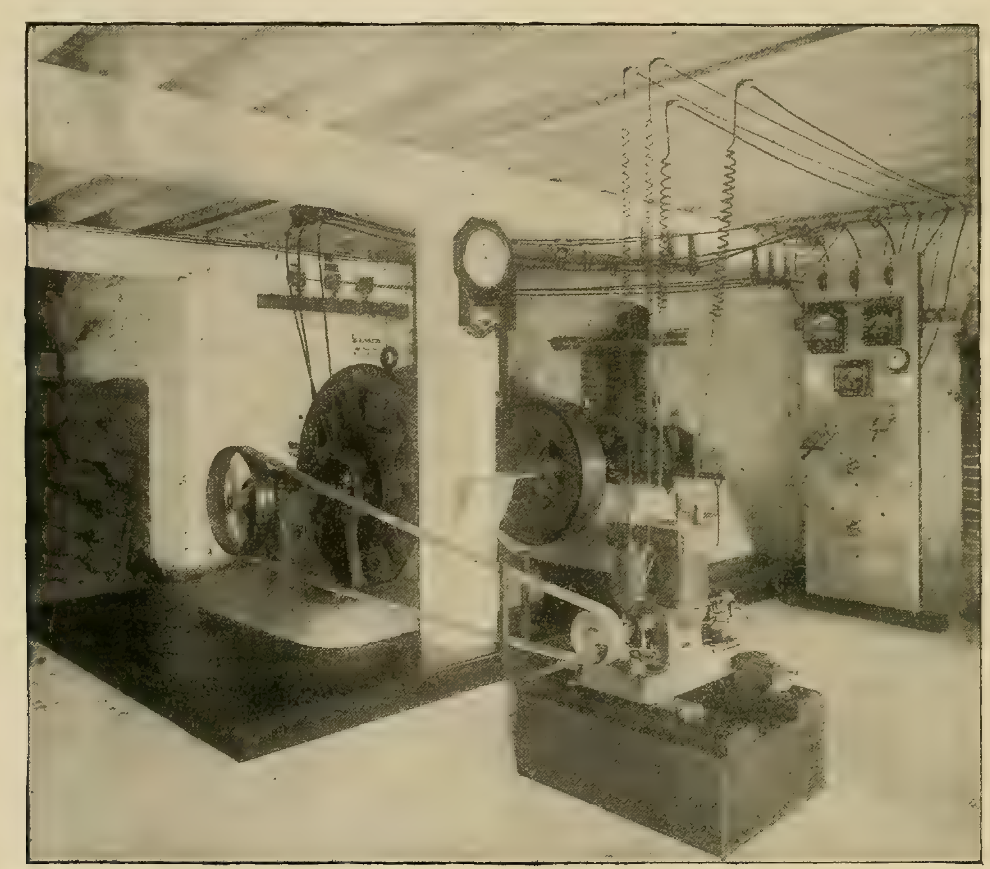
Since the completion of the great three-phase electric power transmissions on the Pacific Coast, between Folsom and Sacramento, and the San Joaquin and Fresno, the use of electricity as a motive power has made great strides. Two of the most important flour mills are now added to the already long list of consumers.

The first to place its dependence on electric motors instead of the steam engine was the Sperry Flour Mill of Fresno. This is driven by a General Electric synchronous motor of 150 kilowatt capacity running at 600 revolutions. The illustration shows this motor with a small bipolar motor to bring it up to speed, in the basement of the mill whence the main belt passes to the rolling and grinding machinery above.

The second mill is the second in importance on the Pacific Coast and the largest flour mill in the United States using electricity instead of steam. Its electrical equipment consists of three General Electric three-phase alternating current induction motors operating at a pressure of 500 volts. The largest of the three motors has a capacity of 75 h. p. This is belted to the main shaft of the mill and drives all the flour making machinery. It runs continuously for twenty-four hours, and for three months without stop. The second largest motor is one of 30 h. p. This occupies a position on the second floor of the mill and drives all the cleaning machinery. It runs continuously for eighteen hours daily. The third is a 20 h. p. motor, and is placed in the basement near the 75 h. p. motor. This drives the roll for grinding the corn and the barley. Its work is intermittent and it runs from eight to ten hours per day only.

The power consumed by the motors is registered by means of recording meters which show the total horsepower of current consumed. These meters register exactly the power used and allow the Company to keep a careful watch upon their machinery, and obtain the highest economy in operation. For instance, when the cleaning for the day is completed, and the 30 h. p. motor and all the cleaning machinery are shut down, all expenses for power in that department cease at once. No power is wasted in running idle shafting and belting. The same is true in a still greater degree in the corn and barley crushing department, where the work is more intermittent.

Still another source of saving lies in the fact that neither engineer nor fireman is required to operate the mill electrically. The motors are so simple in their operation that any employee about the mill can handle them. To start the motor, a simple switch is closed and a lever on the motor thrown over. In less than a minute the motor begins to perform its full load of work and continues without further attention from the operator. The stoppage of the motor is an equally simple process. No attention is required beyond this, except that entailed in keeping the motor lubricated. Power is always ready at call but the mill is not put to one penny of expense for power after the machinery ceases to operate. In addition to this economy, the wear and tear on belts, bearings and machinery is reduced to a minimum by the system of sub-division of power which has been adopted. The cost of hauling coal from the river to the mill, which is in the center of the city, is also saved. It is estimated that the economy in actual power consumed in the Phoenix Mill by the present method of driving, is not less than 15 per cent, and the total saving in the entire cost of operation will pay for the electric motors,



THE 150 KILOWATT SYNCHRONOUS MOTOR IN THE SPERRY FLOUR MILL AT FRESNO

their installation and adptation in less than one year.

In addition to the economy in the operation of the mill by the introduction of electricity as the motive power, a considerable amount of space has also been saved as will readily be realized, and the room formerly occupied by the driving machinery can now be utilized for other machinery or for storage purposes. The present capacity of the Phoenix Mill is 275 barrels of flour and 20 tons of rolled barley and feed, every twenty-four hours, and the entire output of this mill is taken by local consumption, none of the product being shipped outside of the State. It was due to the careful investigation of the subject by Mr. J. H. Arnold, the manager, that electricity was adopted as a motive power. He is already reaping his reward for himself and his Company in benefits constantly accruing.

Personal

Dr. Phillip Mills Jones has been appointed to the Chair of Electro-Physics and Electro-Therapeuty of the Medical Department of the University of California.

Mr. L. E. Marsh, formerly of the San Francisco office of the Pacific Telephone and Telegraph Company, has been promoted to the managership of the Spokane, Wash., exchange of the Inland Telephone and Telegraph Company.

Mr. E. C. Jones has received a well merited promotion from the position of Gas Engineer of the San Francisco Gas and Electric Company to that of Engineer-in-Chief, vice Mr. J. B. Crockett, resigned, who will hereafter devote his entire time to the duties of the Presidency of the Company.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

THE THREE-PART INSULATOR PATENT

On February 11th last, the Commissioner of Patents submitted a decision on a motion made to dissolve an interferance that had been granted to Fred M. Locke, of Victor, N. Y., relative to the three-part or multi-glaze heretofore described in these columns as the "Boch Multi-Glaze Insulator. The interference is numbered 13,969 and the examiner's decision is as follows:

Dissolution of this interference is asked by Boch on the grounds:

First, that Locke's claims are not patentable;

Second, that Locke has no right to make the claims;

Third, that there has been such irregularity in declaring the interference as will preclude the proper determination of the question of priority of invention, and

Fourth, that no interference in fact exists.

The issue of the interference is as follows:

"An insulator formed of two or more shells of suitable insulating material, and which are secured together by inserting one into the other, and then fusing them so as to form practically a single piece."

By inadvertence this is said in the letter to the Examiner of Interference to be substantially claim 3 of Boch. It is really the 3rd claim of Locke. Boch's claims included in the interference differ from the issue as stated in that they specifically include a layer or layers of glaze as a means of uniting the shells of which the insulator is composed. Upon referring to Boch's specification, it will be seen that the glaze that is interposed is merely the coating of glaze that is ordinarily found on porcelain ware. Locke says nothing about the glaze, but it is fair to presume in the absence of proof to the contrary that he employed the usual and ordinary processes of porcelain manufacture. An insulator was shown at the hearing on the motion that was said to be one of Locke's, which was made of two pieces cemented together with what appeared to be sulphur, but there was no evidence that it was what the application of Locke in this interference was intended to cover. Locke says that he connects the shells by "placing of one within the other and then fusing or otherwise securing them together." The words "or otherwise securing" have been stricken from the claims in view of a reference, and have no signification in the description. The Examiner is clearly of the opinion that the terms of the description and claims require that after the shells are put together, the temperature must be raised so high that the parts become, at least superficially soft and adhesive, so that they become practically a single piece.

The issue is in the terms of the broad claim of Locke, as it must necessarily be according to practice in the office.

The Examiner fails to find in the references cited in support of the motion anything to show either that Locke's claims are not patentable or that Locke is not entitled to make the claims in his application. There is an interference in fact between Locke's generic and Boch's specific claims, and no irregularity in the declaration is found that would preclude a proper determination of the question at issue.

The motion is denied. If there is any ground for the third and fourth reasons for dissolution that is not based on the first and second, appeal may be taken thereon on or before the 24th day of February, 1898.

SOMETHING NEW IN THE PUMP LINE.

The general form and construction of the Quimby Screw Pump is illustrated herewith. The four screws that act as pistons in propelling the water are mounted in pairs on parallel shafts and are so arranged that in each pair the thread of one screw projects to the bottom of the space bewteen the threads of the opposite screws. The screw threads have flat faces and peculiarly undercut sides; the width of the face and the base of the thread being one-half the pitch. The pump cylinder fits the perimeters of the threads, as shown in the figure. Space enough is left between the screws and the cylinder and between the faces of the intermeshing threads to allow a close running fit without actual contact. There is no end thrust of the screws in their bearings, because the back pressure of the column of liquid is delivered to the middle of the cylinder and the endwise pressure upon the screws in one direction is exactly counterbalanced by a like pressure in the opposite direction.

The suction connection opens into a chamber underneath the pump cylinder. The suction liquid passes through this chamber to the two ends of the cylinder and is forced from the two ends toward the center by the action of the two pairs of intermeshing threads; the discharge being in the middle of the top of the cylinder, as shown at D. The power to drive the pump is applied to one of the shafts, and the second shaft is driven by means of a pair of gears, shown at G.

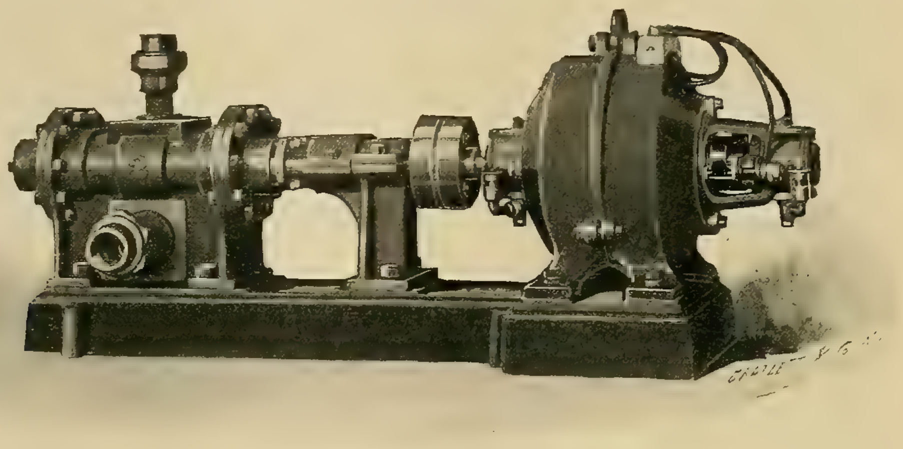
The pump has no internal packing, no valves, no small moving parts and runs without pulsation. The only packing is in the stuffing boxes where the two shafts pass through the cylinder head. As these stuffing boxes are on the suction end of the pump ther is no tendency to blow out the packing.

Among the advantages of the Quimby Pump may be stated that whether driven by a belt, an electric motor, or a steam engine, the driving power is applied directly and without the loss due to intermediate mechanism. Having no valves, no internal packing, and no small moving parts, there is very little opportunity for the pump to get out of order; and as the screws are not in contact with the cylinder or with each other, the consequent absence of wearing surfaces gives the pump great durability. To appreciate the simplicity of the Quimby Pump it should be compared with other pressure pumps in common use, either of duplex or triplex pattern, and particularly in the case of electrically driven pumps.

These pumps have a very high efficiency against a wide range of pressures for the following reasons: The power is applied direct. The thrust due to the back pressure of the column of liquid in the delivery pipe is perfectly balanced. The absence of rubbing surfaces and consequent absence of internal friction. The rotary motion of all the moving parts and the continuous flow of the liquid delivered. Furthermore, as the action of the screws on the liquid is continuous, the delivery is free from pulsation. By thus keeping the liquid in constant and uniform motion the efficiency of the pump is increased, and the pump is made peculiarly suitable for certain specific purposes. Reciproating and centrifugal pumps have a churning effect upon the liquids handled. This churning effect is avoided by the pulseless delivery of the Quimby Pump.

Where pumps with valves are used to handle thick liquids, the operation of the valves is apt to be deranged by the liquid so as to greatly lessen the efficiency of the pump. Owing to the absence of valves and to the fact that the column of liquid is kept in constant and uniform motion, the Quimby Pump handles thick liquids such as asphalt, soap or syrup easily and efficiently.

As a Rotary Pump, efficient against considerable pressures and running at high speed, the Quimby Pump is an ideal one for direct-connected electric work. The pump and motor are mounted on the same bed plate, and the motor shaft is coupled directly to one of the pump shafts, as in this way the number of moving parts is reduced to a minimum, with a constant reduction of care and expense for repairs and an increase of efficiency. Another advantage of this construction is the small amount of floor space occupied.



THE QUIMBY PUMP

The Quimby Electric Pump has features which make it especially valuable in connection with the hydro-electric operation of elevators. These pumps have been in use for elevator service for sereral years with very satisfactory results, and have been successfully applied to the pressure tank system, the gravity system, and in pumping directly into the elevator cylinder.

The single illustration of direct pumping will show the marked superiority of the Quimby pump for elevator works. In their ability to pump directly into the elevator cylinder, these pumps are unique, for, with an absolutely pulseless delivery, they have a very high efficiency, a characteristic found in no other pump on the market. The mutiplication of cylinders in a reciprocating pump diminishes the intensity of the pulsations by increasing their frequency, but does not entirely remove the pulsations. Where the Quimby Pump has been applied to pumping directly into the elevator cylinder, the motion of the car is as smooth as in the pressure tank system. The advantage of direct pumping is that the pressure against which the pump works is proportional to the load in the car, and as the average elevator load is about half the maximum load, the saving in comparison with the pressure tank system is obvious. Where an elevator has been operated by water from the city mains, a considerable saving can usually be effected in the cost of operation, and the service much improved by the application of an electric pump.

The Quimby Pump, either as a power pump or an electric pump, has advantages for use in refineries that are peculiar to itself. In pumping into long pipe lines any pulsation in the pump delivery adds to the difficulty of keeping the pipe joints tight. The Quimby Pump has an absolutely pulseless delivery, coupled with a very high efficiency. These pumps will handle thick products, hot tar, pitch, etc. The pumps are very strongly built, will stand hard use and are moderate in price when compared with other well-made power pumps.

Where steam pumps are situated a long distance from the boilers, the loss of power in the pipes is very great. In such cases a great saving can be made by using electric pumps, for the loss of power in electric lines is comparatively light. The manufacture of alternating motors without commutators, and consequently without the danger of sparks, has made it possible to use electricity in refineries where it could not have been used before and its use in paper mills should particularly commend itself, because of its high efficiency, its strong construction, its pulseless delivery and its ability to handle thick semi-fluids, like paper stock.

The Quimby pump may be seen in operation at the exhibition rooms of Chas. C. Moore & Co., 32 Front St., San Francisco, from whom information, catalogues and prices may be obtained on application in person or by mail.

TABLE OF CONTENTS.

Illustrated articles are indicated by an asterisk (*)

Editorial

Are News Notes Wanted.... 120
Proof Positive of Great Circulation.... 120
Standard Electrical Diagrams...... 121
Progress of the Niagara-Buffalo Transmission.. 116

Transmission

*The Pioneer Electric Power Transmission.. 109
Properties of High Potential Insulators, by Albert T. Bell..115
*Electric Power in Large Units...... 122

Illumination

*Electricity on a Lightship.... 119

Passing Comment

An Exceptionally Excellent Edition.. 121
The Waning of the Welsbach.......... 121

Electro-Therapeuty

*A Large Electro-Magnet for Oculists' Use, by Phillip Mills Jones, M. D....... 117

Personal

Marsh, L. E....... 123
Jones, E. C..... 123
Jones, Philip Mills, M. D...... 123

Industrial

*The Quimby Pump... 124
The "Electra" Carbons.... 123
The Three-Part Insulator Patent.... 123

The Journal of Electricity

Vol. V. APRIL, 1898. No. 7

Alternate Current Workings

By DONALD H. FRY.

Part 1

Alternating Currents.

ALTERNATING currents are becoming more and more of interest to electricians, especially on the Pacific Coast where long distance transmissions are so prevalent for owing to the high voltages that can be attained and to the fact that it is possible to step up or step down to any required voltage, the alternating current is peculiarly adapted to long distance work. In fact, with possibly one exception in Switzerland, there are no long direct current transmissions. The object of the present series of articles is, therefore, to make clear some points in alternating currents not generally understood, avoiding mathematics as much as possible, and to briefly show wherein they fundamentally differ in nature from direct currents.

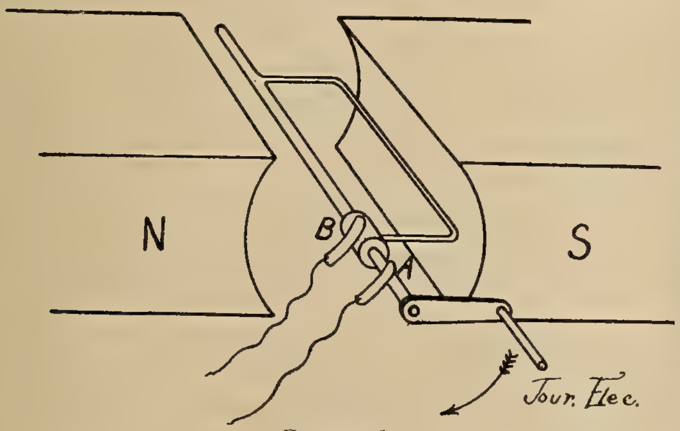


Figure 1

The alternating current is so called because it is continually undergoing a succession of rapid reversals. The electro-motive force rises and falls in periodic waves and thus causes the electricity or current to oscillate forward and backward with great rapidity. To illustrate how such a current is generated we will take the simplest form of an alternator,—a single wire revolving in a uniform magnetic field as shown in figure 1. One end of the wire is connected to the axis and the other to the metal sleeve B, insulated from the axis by a fibre brushing. The difference of potential between the sleeve B and some point on the axis A, is proportional to the rate at which the wire is cutting the magnetic lines of force crossing from N to S. When the loop is horizontal or parallel to the lines of force as shown in the figure, the rate of cutting is a maximum, but when the crank has been turned through 90 deg. and the plane of the loop is vertical, the wire will be traveling in the same direction as the lines of force and the rate of cutting will be zero. An instant later the wire will have passed the zero point and be cutting the lines in the opposite direction and the potential between B and A will be negative—that is, B will be negative to A. When the crank has turned through half a revolution and the loop has reached a horizontal position again, the potential will be at a negative maximum; and so on through zero to a positive maximum in one complete revolution. If now we place rubbing contacts at A and B and connect them by a closed circuit, a current will flow from B to A and again from A to B during each revolution and we have an alternating current. The generation of direct currents is precisely the same with the addition of a commutator or rectifying device to keep the current flowing in one direction.

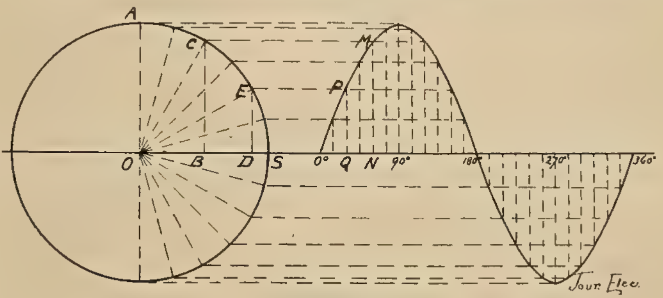


Figure 2

We have assumed the field to be uniform, and should the rate of rotation be kept constant, it is an easy matter to derive a graphic representation of the relation between

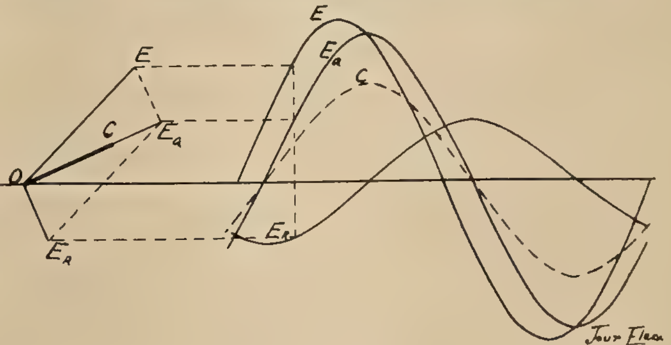


Figure 3

time and electro-motive force, for by plotting the angles of the crank (which are proportional to time) on the horizontal, and the electro-motive force on the vertical (figure 2) we accomplish this and the curve the electro-motive force follows is a true sine curve. If OA, proportional to the maximum rate of cutting lines of force, be taken as unity, M N, equal to C B is proportional to the rate of cutting when the wire is in the position C, and C B is the sine of the angle S O C; likewise P Q = E D is the sine of the angle S O E, which shows whence the name sine curve is derived.

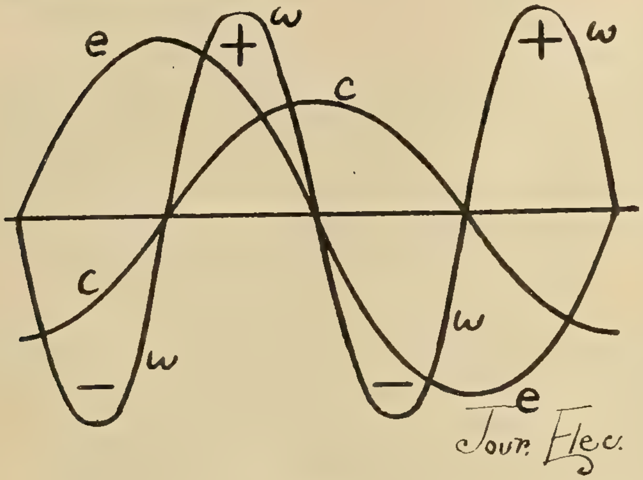


Figure 4

In practice the sine curve cannot be followed exactly owing to the fact that there are many wires in a coil instead of one, and it is impossible to procure a perfectly uniform field. However as a sine curve variation gives a minimum inductance it is desirable to follow it as closely as possible, especially in long transmissions where the induction of the line becomes an important item, and therefore most of the best modern machines approximate a sine curve very closely. This is accomplished by carefully proportioning the pole pieces, armature teeth and air gap. Also, since a motor should follow closely the same electro-motive force and current variations as the dynamo running it, the sine curve is resorted to as a standard, else to ensure high efficiency special motors would have to be designed for each generator.

The effective value of the electro-motive force is not the maximum, nor the average value, but the square root of the average square. In the case of the sine curve, taking O A, the maximum value, as unity, the average pressure is $2/\pi = .637$, but the effective value,—and it is the effective value only that concerns the practical electrician—is $\sqrt{\text{av. } e^2} = \frac{1}{\sqrt{2}} = .707$. Hereafter E will designate the effective electro-motive force and C the effective current.

The properties of alternating currents differ somewhat from those of direct, for they are affected not only by the resistance of the circuit, but also by its induction. Self-induction may be compared to the inertia of a moving body and in fact it is the inertia of the moving current, which tends to retard the current in its rapid reversals, and so causes it to lag somewhat behind its electro-motive force—or, in other words, to throw it out of phase. The alternating current sets up a counter electro-motive force, which is proportional to its rate of change; or in other words, again, this counter pressure is a retarding field caused by the current itself and though it has the same period as the current, it is out of unison with it and follows behind by an angle of 90 degrees, thus tending to hold the current back. As this counter pressure is in a measure opposed to the impressed pressure, only part of the latter is effective in producing current, and this part, which we may call the active pressure, is seen to be—Ea (figure 3)—the resultant of E, the impressed pressure, and Er, the counter pressure. In phase, Er is always 90 degrees behind Ea, while Ea lags somewhat behind E. The current, represented by the heavy line O C, in the diagram, and the dotted curve, is proportional to Ea, and is in phase with it, and so also lags behind E by the same angle ϕ, which is termed the angle of lag.

The angle of lag varies greatly in degree:—from 0, as is the case where there is no induction and C is in phase with E, to almost 90 degrees, when iron is so introduced into the circuit as to strengthen the opposing field, thereby causing the counter pressure to be greatly increased. That C should lag behind E, so modifying the law of Ohm $C=\frac{E}{R}$ and causing the current to be reduced in value, is by no means the disadvantage that it might at first seem, but on the other hand it has distinct advantages. For instance, a machine of moderately high self-inductance can not be burnt out on a short circuit, for the current chokes itself, as it were, and the apparent resistance, called impedance, prevents the current from attaining dangerous proportions by throwing it out of phase with the electro-motive force. It is due to this difference of phase—this variable lagging of the current, that synchronous motors will not fall out of step with their generator, even under great and sudden changes of load; to this also is due the fact that transformers and induction motors may be run efficiently on light load.

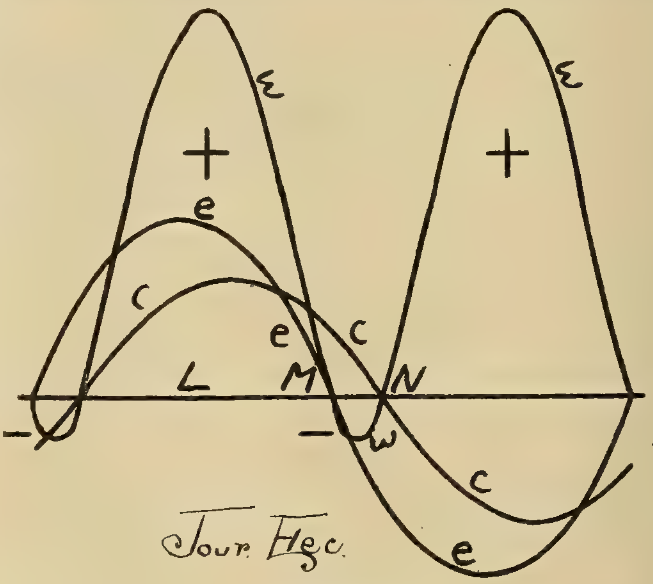
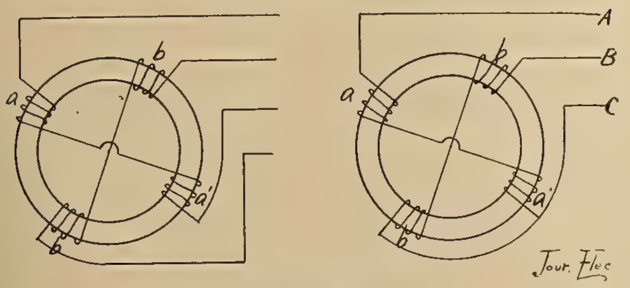


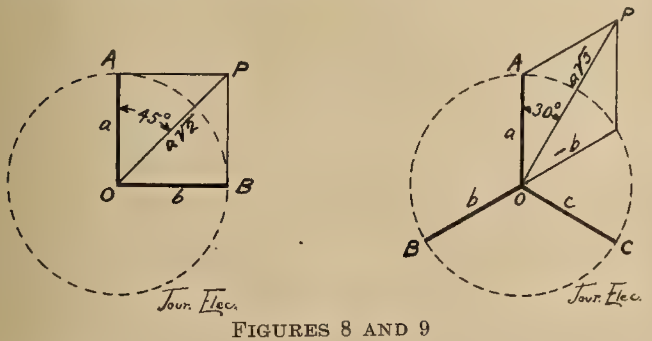
Figure 5

Unlike direct current, the energy of an alternating current circuit is not the product of the amperes by the volts, except in the case where there is no inductance, or where the circuit has slight inductance that is so counteracted by the capacity of the circuit that the current is in phase with its electro-motive force, in which event the energy of the alternating current circuit is found in the product of the instantaneous values of e and c.



FIGURES 6 AND 7

In figure 4, e represents the electro-motive force, and c the lagging current, while the third curve w is the watts curve which is derived by multiplying the ordinates of e and c and plotting the product to some convenient scale. At the point L, both e and c have positive values and therefore their product is positive; at M, e passes through o and therefore w also passes through o. Between M and N, e is negative and c positive, so their product is negative, and w falls below the zero line, but at N the current is o and w again crosses the line, while beyond N both e and c are negative and their product therefore positive. The effective watts is represented by the difference between the positive + loop and the small negative (—) loop of the curve w. If the current were in phase with the electro-motive force there would be no negative loop, but if it should lag a full 90 degrees or quarter period the negative and positive loops would be equal—figure 5—and the current would be wattless:—that is, it would possess no energy whatever. This extreme case is never reached, however, though it is closely approximated in the case of the primary current in a transformer when the secondary circuit is open, for here the circuit contains very high inductance, due to the presence of the iron and comparatively low resistance.



FIGURES 8 AND 9

The ratio of the true energy consumed to the apparent energy of a circuit, or the ratio of the true watts to the volt-amperes—C E—is called the power factor. The true watts obtained from any reliable watt-meter are equal to C E times the cosine of the angle of lag. The power-factor is therefore equal to the cos. of the angle of lag and when the current and the electro-motive force are in phase the angle of lag is o, while its cosine is a maximum and equal to 1 and consequently the power factor is a maximum or 100 per cent. The term apparent efficiency is sometimes used in conection with alternating current motors and is applied to the ratio of the total output in watts to the volt-ampere in-put, and so is really the product of the true efficiency and the power factor.

The number of complete cycles that an alternating current passes through in one second is called its frequency; the curve in figure 2 represents one complete cycle. Alternations is a term frequently used to express the number of reversals of half cycles, but as this is usually given per minute, it is necessary to divide it by 2×60 or 120 to derive the frequency. For example, a current of 7200 alternations has a frenquency of $\frac{7200}{120}=60$ It would be well if this term alternations were entirely abolished. It only lends confusion, for in all alternating current calculations the number of complete cycles per seond is used, not the number of half cycles; also in electro-magnetic work the second is the unit of time and not the minute.

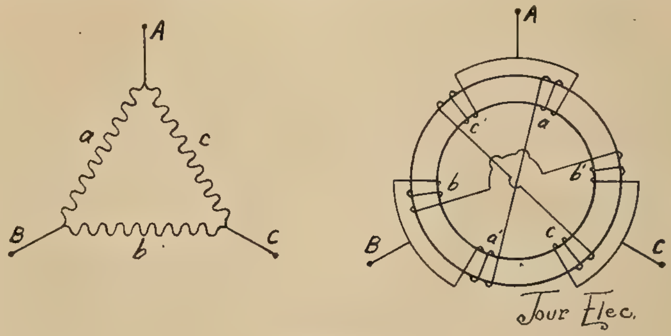


FIGURE 10

When alternating current machinery first came into use all sorts of frequencies were tried ranging from 25 to 160, but this state of affairs was unsatisfactory and the apparent need of a standard manifested itself. At low frequencies—anywhere below 40—the blinking of the lights is quite perceptible, while the transformer losses are greater at low frequency than at high. This led to the larger electrical companies each adopting a standard of its own, but generally ranging from 100 to 133, as that was most satisfactory for lighting purposes. Later, as induction motors were introduced, other factors entered into the problem; the speed of the motor varies directly with the frequency and inversely as the number of poles, so to reduce the speed of small units to reasonable limits, either the frequency had to be reduced or the number of poles increased, and as it is impractical to build small motors with a large number of poles, the former method had to be resorted to, with the result that a frequency of 60 has been almost universally adopted where power and lights are furnished from the same machine—this compromise being very satisfactory for both. There were two other reasons for adopting the lower standard. The line reactance varies directly with the frequency, and therefore with a higher frequency the induction of the line is increased with a consequent greater line drop—quite an important item in long distance transmissions. Also with the growth of stations came the advisability of coupling dynamos in parallel, and while machines of high frequency run well together under full load, at light load they are apt to shirk and divide the load unevenly—an objection not applicable to low frequency generators.

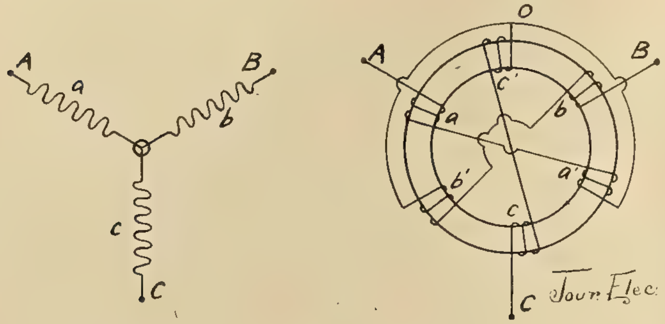


FIGURE 11

Part ii

POLYPHASE CURRENTS.

A SINGE-PHASE alternating current is not practical for large power transmissions because single-phase motors are comparatively inefficient and costly; added to which they are not self-starting unless some special starting device is resorted to, which practically prohibits the use of units much over 10 horse-power. Of course this does not apply to large synchronous motors running continuously, for here the difficulty of a small starting motor is of minor importance, but it is a rare case where a system consists of large synchronous motors only, and for this reason polyphase systems are used. They are essentially two or three, or in very rare cases, more than three separate and distinct alternating currents of the same frequency but of different phase, and while they embody all the advantages of the single phase system, they in addition overcome many of the most serious disadvantages attending single phase work.

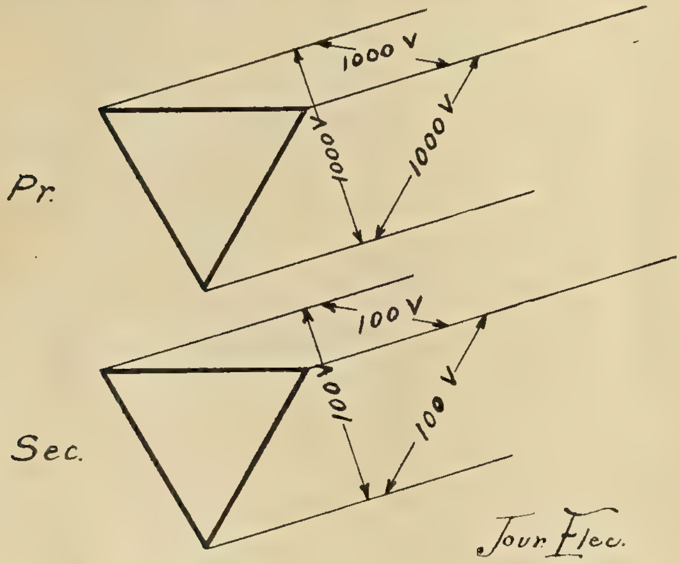


FIGURE 12--PRIMARY, DELTA; SECONDARY, DELTA.

When two currents are produced by the same machine it is called a two phase dynamo, and the windings are spaced 90 electrical degrees apart, so that there is a difference of one-quarter of a period or cycle between the currents in the two phases,—when one is a maximum the other is zero. If the system consists of three currents, it is called a three phase system and is operated with a difference of 120 degrees between each of three phases.

There are two ways of transmitting two phase currents: First, with the circuits entirely independent of one another, in which case four main wires are required as in figure 6, or second, when the two circuits have a common return wire and three wires only are used as in figure 7. The value or amount of current in the third or common return wire C is at any instant equal to the algebraic sum of the currents in the other two wires, and its effective value is equal to the resultant of the separate currents or to their vector sum. Provided the system is balanced by a load evenly divided between the two phases, this value is equal to $\sqrt{2}$ C, where C is the current in one circuit.

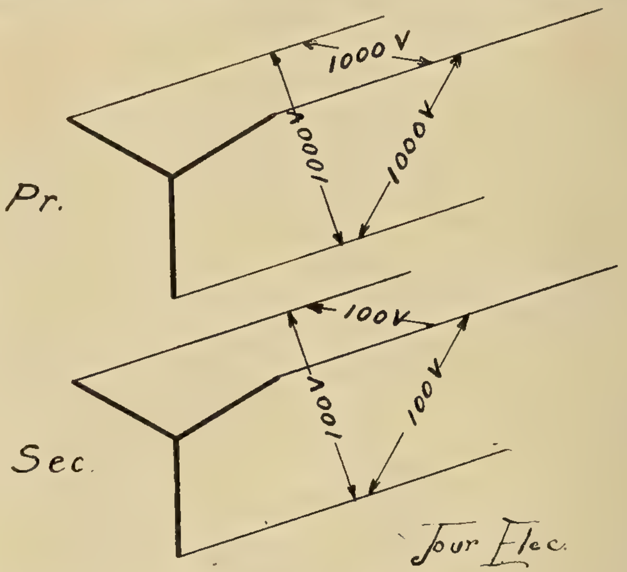


FIGURE 13—PRIMARY "Y," SECONDARY "Y."

This can best be illustrated by the parallelogram of forces as shown in figure 8 where a and b represent the current in the wires A and B, and are equal in value, though a is 90 degrees ahead of b in phase. The current in the common return wire C is equal to O P or a $\sqrt{2}$ and in phase it is half-way between a and b, or lags behind a by 45 degrees.

In a three phase system, instead of using six wires to form three separate circuits, it is customary in practice to save copper by transmitting on a circuit consisting of three wires. This is done in several ways, but all depending on the manner in which the coils of the machine are connected up.

When the coils of a three phase machine are so connected as to form the three sides of an equilateral triangle, the leads being connected to the three corners of the winding, it is termed a delta connection from the Greek symbol △, which it resembles. The pressure between any two line wires is that generated by one coil, that is, the coils of one phase, while the current in each wire is equal to the vector sum of the currents in the two adjacent coils to which it is attached, and in a balanced system this is equal to 2 C cos. 30 degrees, or $\sqrt{3}$ C, —C being the current in one coil. In figure 9, a, b and c are the three currents in the coils; the current carried by each of the line wires is O P, or a $\sqrt{3}$

Another way of connecting a three phase system is shown in figure 11 in which one end of each coil is connected to the three transmission leads, the other three ends being connected together at a common or neutral point, for the algebraic sum of these currents must at all times be zero. This is called a "star" or "Y" winding. The pressure between any two line wires is $\sqrt{3}$ E, where E is the pressure generated by one set of coils, as can be shown by taking a, b and c in figure 9 as voltages instead of currents, but in this case it is evident that the current in each line wire is the same as that generated in the coil to which it is connected.

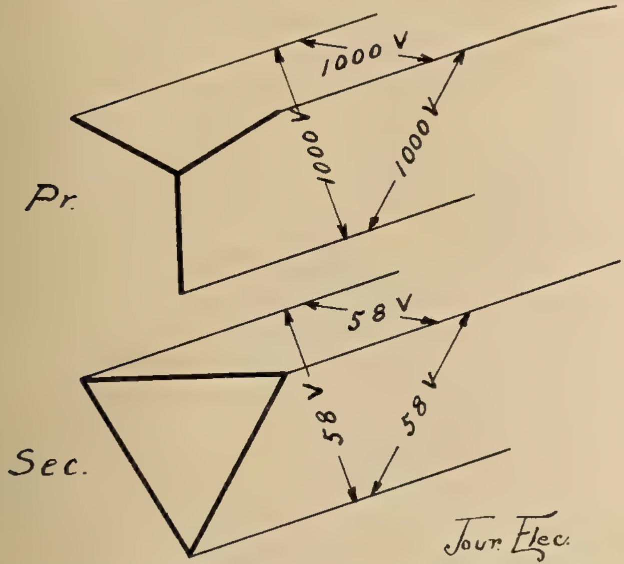


Figure 14—Primary "Y," Secondary Delta.

Various other ways of connecting up the coils of a three phaser have been devised by Dobrowolsky and others, but they are all combinations of the delta and Y and the special advantages claimed for them are, like the particular beauty of each individual infant, more or less in the fond imagination of the authors of their being.

When stepping down from the mains of a three phase system for lighting purposes, if the number of lights be small, as in a private house or small store or office, it is usual to place a single transformer across one leg, but where the number of lights is large, transformers are connected across all three legs and the secondaries are also run on three wires. When either the primary or the secondary leads are connected two and two so that they form a triangle, they are connected delta, but when one terminal from each is joined in a common center and the three free ends are connected to the three mains, they are said to be Y. By making different combinations of the primary and secondary connections three different voltages can be obtained off the secondary. For example, let us assume the ratio of the primary to the secondary of our transformers to be 10 to 1, and the pressure between our primary mains 1000 volts.

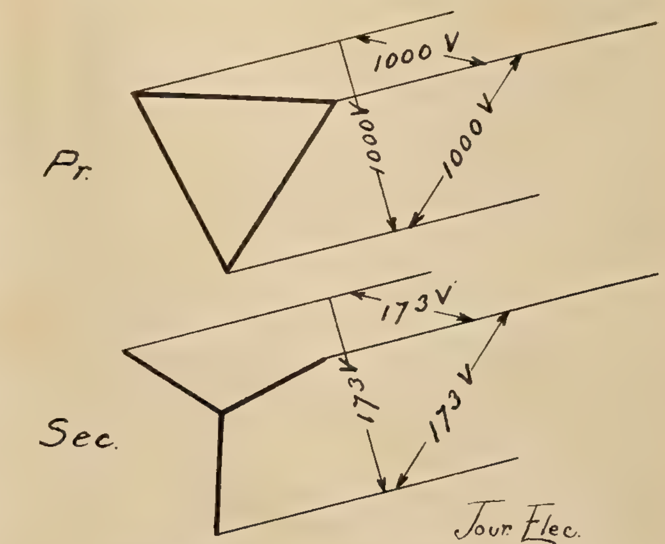


Figure 15—Primary, Delta; Secondary, "Y."

(1) If both the primary and secondary are delta connected as shown in figure 12, it is clear that the pressure on the primary turns is the full 1000 volts and that the pressures across the secondary mains is the same as in secondary windings of the transformers—100 volts.

(2) Connecting both primary and secondary Y (figure 13) we gain the same result but in a different way, for the pressure across the primary coils is not 1000 volts, but $\frac{1000}{\sqrt{3}}$ or 578. The pressure the secondaries are subjected to is 58, but yet the secondaries are 100 volts, for again turning to figure 9, let the points A B and C represent the three secondary leads. The pressure in the coil A O is a=58 volts, but between A and B it is O P $=\sqrt{3}$ a=100 volts.

(3) If the primaries are connected Y and the secondaries △ the pressure across the primary coils is as in (2) and stepping down 10 to 1 show the secondaries 58, but in this case the secondary mains are the same as the coils—only 58 volts. This is shown in Figure 14.

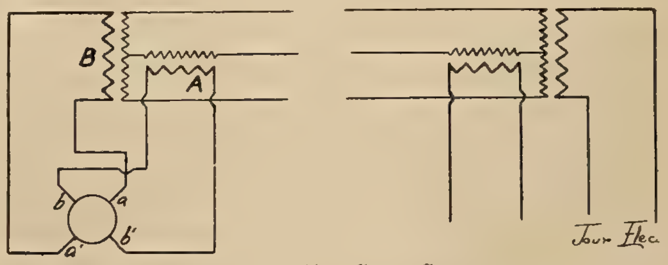


Figure 16—The Scott System.

(4) With the primaries connected in △ and the secondaries Y, the pressure in the primaries is as in (1)—1000 volts. That in the secondaries 100 volts, which gives

$100\sqrt{3}=173$ as the voltage in the mains. This last is the most common connection, because it is the most economical. It is shown in Figure 15.

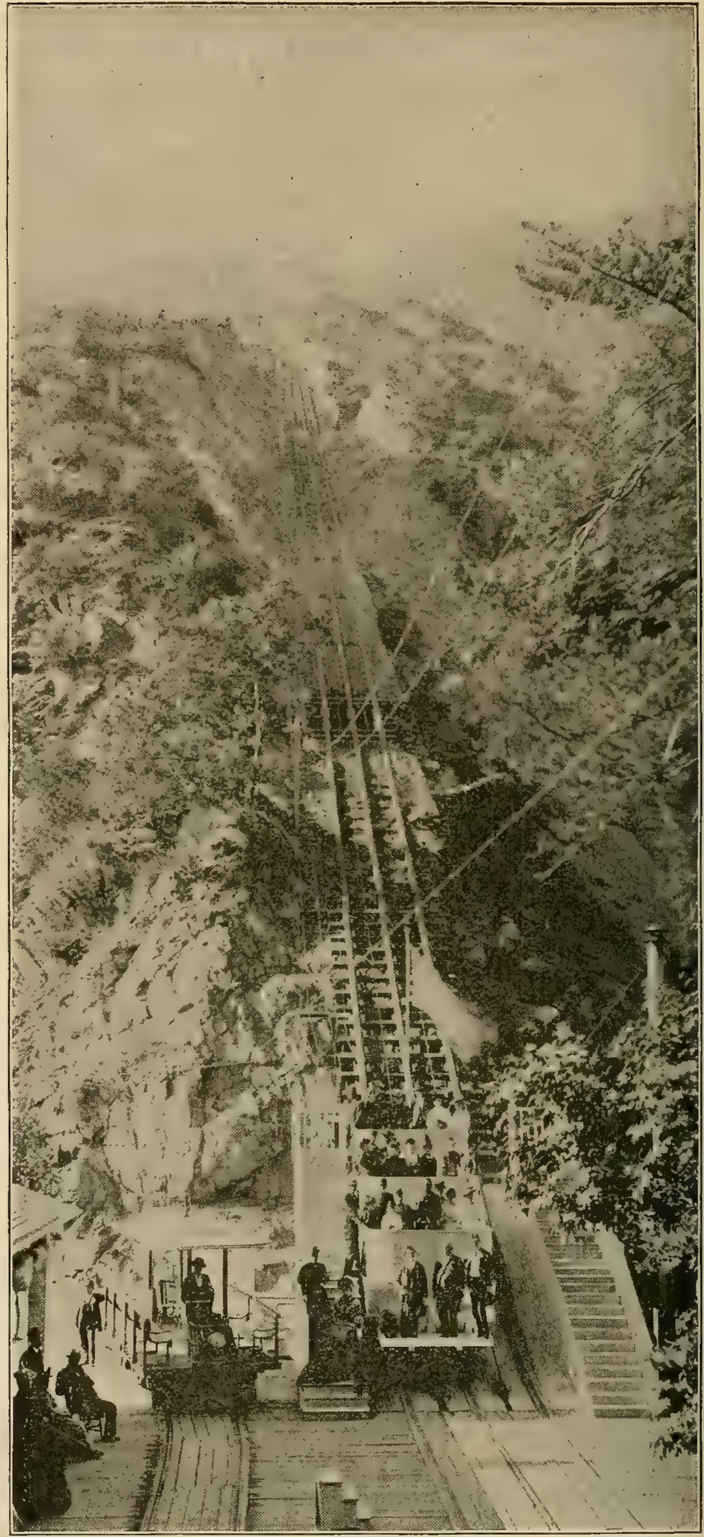
The Scott system of transmission is a method for transforming a two phase current into a three phase current in the stationary step up transformers; of transmitting three phase and again stepping down to two phase for distribution. Thus to the saving of copper by three wire transmission is added the advantage of two phase distribution. To accomplish this, Mr. Scott connects the primaries of two transformers A and B—figure 16—to the leads of a two phase dynamo. The secondaries of these transformers have a different number of turns, A having 0.87 times as many as B. Of the secondary leads of A one is connected to one of the transmission wires, while the other is cut into the middle of the secondary of B as shown. The two B leads are connected to the remaining two wires, and thus three equal pressures 120 degrees apart are obtained. At the further end of the line this process is reversed, and by two similar transformers the three phase current is changed to two phase.

Transportation

DETAILS OF THE MOUNT LOWE RAILWAY.

A correspondent, in discussing the recent reference in these columns to the Mount Lowe Railway, points out an interesting feature of electrical installation that has hitherto been overlooked and which, though hardly worthy of emulation, illustrates the extremities to which the electrical engineer is sometimes driven by the iron clad exaction that come what may, a certain result must be accomplished with an expenditure that may not exceed a given amount. This interesting feature is nothing less than the fact that the 500-volt railway and power circuit, the 1100-volt primary circuit of the alternating incandescent system and the arc lighting system each and all use the rails of the railway system as a common return to the power house. It is understood that this arrangement, which has been operating succesfully for three years or more, is to be displaced by properly constructed independent circuits during the coming summer.

The correspondent also sends the accompanying illustrated of the incline of the Mount Lowe Railway. together with the information that two sources of water supply were available under widely different conditions as to head and quantity, both of which it was desired to utilize. One of the streams comes from the summit of Echo Mountain with a fall of 1,250 feet and the other from Rubio Canyon with a fall of 287 feet, the water from each being brought down to the station in separate lines of pipe and applied to the wheels separately. The power station consists of two Pelton wheels of the steel disc type, mounted on the same shaft with iron housing and bed plate.



Incline of the Mt. Lowe Railway.

The high-head wheel is 40 inches in diameter and developes 100 horse power with a 1-inch nozzle, while the wheel for the lower head is 19 inches in diameter, to which are applied two streams developing 50 horsepower, both wheels running at 800 revolutions, the varying diameters being necessary to give the same speed and still conform to the velocity due to their respective heads. The power developed is transmitted to the top of Echo Mountain, where it drives the hoisting machinery of the cable incline here shown, which is 3,000 feet in length and laid on a grade of 48 per cent.

Mining

ELECTRICITY IN MINING.

It is not a difficult matter to convey to managers of mining properties an understanding of the chief terms of electrical parlance, by comparing these terms with the various conditions of water—that agency with the action of which none are more familiar than miners themselves. As one miners inch, the unit of volume of water, delivered under a pressure of 480 feet head, will produce one mechanical horse power, so will one ampere, the unit of volume of electricity, if delivered under a pressure of 746 volts, produce one mechanical horse power. The analogy is practically perfect and the busy man of mining affairs who has to do somewhat with electricity need not necessarily delve into electro-techniques beyond that depth which returns the understanding that almost every electrical term in every day use finds an analogue in a familiar utilization of water.

It has been shown that the ampere is comparable to the miners inch, and that the volt is comparable to the head-in-feet, or the pressure of a stream of water. The power obtainable from a stream of water may be found in the product of its weight and velocity—this product being expressed in "foot-pounds"—and there are 33,000 foot pounds to a horse power. Similarly the power obtained from a current of electricity is found in the product of its amperes (weight or volume) and its volts (pressure or velocity)—this product being expressed in "watts"—and there are 746 watts to a horse power. Where any power of considerable magnitude is under consideration, its equivalent in watts would be so great numerically as to be inconvenient of expression, hence the Greek prefix "kilo" signifying 1,000 is used exactly as in the metric system, and thus the energy of one hundred and seventy-five thousand watts is expressed as 175 kilowatts. Since in the watt is represented the product of volts and amperes, it is obvious that 175 kilowatts, for instance, may represent an energy of 10,000 volts and 17.5 amperes, or that the two factors may have any value which will give 175,000 as their product. Here the cited analogue still holds, for the same is true of the energy of a stream of water when expressed in foot-pounds.

But water in flowing through a pipe line encounters resistance from friction with the sides of the pipe and from bends or other changes in the direction of flow. Hydraulics characterize this resistance as the "co-efficient of resistance," which is a variable quantity, and which is not expressed in terms of standardized unity. It is practically in the same manner that a current of electricity, in traversing a wire, encounters resistance, the amount of which varies greatly with the metal of which the wire is made. Silver offers the least resistance of any metal to the flow of electricity; copper has about 98 per cent of the conductivity of silver, while iron has less than one-sixth of the conductivity of copper. In electricity the unit of resistance is the "ohm" and its value is such that when a pressure of one volt is applied to such a length or cross section of wire that the current which flows through the wire will be one ampere, then the resistance of the wire will be one ohm. A parallel to this would be found in hydraulics where the length and diameter of a pipe is such that under a head of one foot, exactly one miners inch of water would flow through the pipe. The co-efficient of resistance of this pipe is analgous to the term of "ohm"—the unit of electrical resistance.

Electricity, if of the direct current form, traverses the conducting wire in one direction, as does water in a pipe line. Sometimes pulsating currents are used and these, like water in the supply pipe of a hydraulic ram, flow in a single direction, but are interrupted periodically. Then there are alternating currents of electricity which are of a vibrating character and oscillate in one diection and then in the other, alternately, as water would do in a pipe, each end of which is connected to a respective side of a piston chamber having no valves, in which event the direction of flow of water through the pipe would alternate with the direction of the piston stroke.

It is unfortunate for lucid analogy that there is no practical, familiar parallel in hydraulic practices by which the nature of the varieties of alternating currents may be illustrated, and this misfortune is the greater because of the knowledge that alternating currents are destined to take a far more important part in all mining applications of electricity, except in electro-metallurgy, than any other form of the ubiquitous agency called electricity. Hydraulic conditions of suppositional forms must therefore be improvised to complete the analogue.

An oscillating current of the form described, in which electricity flows back and forth as water in a pipe connected to a piston chamber without valves, forms the simplest type of alternating currents, and such a current is termed a "single phase" current. This may be fixed in mind by conceiving the water device to be driven by a single piston, actuated from a single crank disc, throwing the water in the pipe into a state of single oscillation or single alternation—technically "single phase." The rate of this oscillation, when applied electrically, is termed the "periodicity," or the "rate of alternation" of the circuit.

Suppose however, that there are two such single pipes, entirely independent from but paralleling each other, and containing water alternated in flow as in the previous instance, by valveless piston chambers. If the pistons of the respective chambers are always in unison as to speed and position as they would be were they driven from the same crank pin of a shaft, then the volumes of water in the two pipes would pulsate in perfect harmony as to rate, speed and direction, or to use an electrical term, the currents would be in "synchronism." But should the two pistons be actuated from independent crank pins placed diametrically opposite on the driving shaft, then the flow of water in one pipe would be exactly opposite to that of the water in the second pipe, which may be described as a "two current" or "two flow" system. It is precisely such a condition as this which exists in the two electrical circuits of the "two phase" alternating current electric transmission system.

Again, instead of the two valveless chambers and pipe system just described, assume that there are three such systems, each identical in construction to the others, with the solitary exception that the pump pistons are respectively driven from crank pins placed 120 degrees apart on a shaft, in which event the direction of flow in pipe No. 2 will be one-third of a stroke or revolution behind that in pipe No. 1. Similarly, system No. 3 will "lag" one-third of a stroke behind No. 2; system No. 1 will lag one-third of a stroke behind No. 3, and so on, all this being analgous to a "three-phase" alternating current system. Thus are illustrated the different types of polyphase systems,—as all varieties of alternating currents in excess of the single phase system are termed.

But what is the advantage of different phases? Simply this: As hot water in flowing through a pipe influences the temperature of the air surrounding it, so does electricity in flowing through a wire influence the ether surrounding the wire,—in fact, magnetizes it, the direction of magnetic pull (so to speak) varying with the direction of electric current flow. A north magnetic polarity and a south magnetic polarity will attract each other as all know, and owing to the fact that in two-phase systems the direction of electric current flow in the two circuits is always exactly opposite, the ether surrounding one wire is always of exactly opposite magnetic polarity to the ether surrounding the other wire, hence in two-phase electric motors there is always a state of mutual magnetic attraction between that part o the motor conaining the "leading" phase and that part of the motor containing the "lagging" phase.

Single phase circuits are by nature restricted to but a single magnetic polarity of the surrounding ether at a given interval, and as it takes opposite magnetic polarities to exert attraction toward each other, it is evident that the production of power from single phase current is seriously handicapped by its own inherent characteristic. This idea roughly explains why the development of single phase motors is so tardy.

In three phase systems, the phase impulses follow each other consecutively with absolute regularity, and inasmuch as "fields" or atmospheres of magnetism attend the appearance or disappearance of each impulse, it is evident that the revolving motion of these consecutive impulses impart a similar rotation to the attending magnetic field, which explains the term "rotating field." If a strong magnetic field revolves, obviously any magnetic body placed within that field will tend to revolve with it and to this principle is due the three phase motor.

Finally, the transformer or converter is just what its name indicates, or rather, what its name would indicate were the word electricity prefixed. It is merely a deice for automatically transforming electrical energy or "wattage" from one value to another. The transformer is to electricity what an appliance would be to hydraulics that would take the energy of a small stream of water at high head and transform it with but small loss to the energy of a large stream of water at low head, or vice versa. Were there an equivalent appliance in hydraulics, this "hydraulic transformer" could automatically convert the irrisistable tidal flow, or any portion of it, to a much smaller volume of water at a tremenduously high head, thereby enabling an easy solution of the long hoped for utilization of the tides for power purposes.

It must be borne in mind that the foregoing has been written with the idea of imparting most elementary ideas to those who have neither time nor inclination to become possessed of any but a superficial knowledge of the chief terms and principles which are fundamental in electrical practices. The wisdom of experience has well taught that "a little knowledge is a dangerous thing," and the above is a little, indeed a very, very little, of the knowledge of which science is possessed concerning electricity, and to accept every statement given as an indisputable exposition of most recent practices would be an error, for, as intimated, an elementary and brief explanation of a profound subject can not be swerved from its purpose by considerations other than those of the barest generalities.

Electro-Therapeuty

RECENT USES OF ELECTRICITY IN MEDICINE.

By Philip Mills Jones, M. D.

THE very general interest in the work and value of the X-rays, seems to have aroused a new interest in electro-therapeutics generally, for certainly there are more items in the medical press on things electrical than was the case two or three years ago. I note several "new treatments" that are old, almost as old as electric-therapeutics itself. There are also some things noted that are new and that seem to be really valuable; certainly the signs of renewed interest in electricity is promising if nothing more.

Dr. John Winslow, in the "Medical Record" for February 26th, reports a case of hysterical aphonia treated by the induced currents and cured. He found that if the apparatus was so arranged that the induction coil would be heard to operate by the patient and the circuit from the secondary to the patient left open, the relief would be just as certain, thus demonstrating that the action of the currents, per se, had nothing to do with the actual cure of the patient. The experiment was cleverly planned, but why a switch should be called a "rheotome", is something quite beyond the comprehension of the writer.

Dr. Alex. J. C. Skeen, in an article in the "American Medico-Surgical Bulletin", has discovered that the electro-cautery (why "galvano-cautery"?) and the use of the constant direct current in sufficient current strengths to produce electrolysis, are excellent in the treatment of certain forms of neoplasm of the skin and mucous membrane. He reports the result of his use of these methods of treatment in a number of cases, principally of naevus and epithelioma, in which a perfectly satisfactory result was obtained. There seems to be nothing new in the article, except the addition to the list of cures of three more cases.

The "Philadelphia Medical News," the new medical journal of Philadelphia of which Dr. Geo. M. Gould is editor, states in its issue for March 12th, that during 1897 there were 416 cases examined by the X-rays at the St. Thomas' Hospital, London, England. This number may seem large considering the short time that the rays have been in use, but the writer examined during the same time, a few over three hundred cases, and but a small number of these were hospital cases. The same journal is responsible for the statement that there is a proposition, in Paris, France, to establish a radiographic service in each of the hospitals under the control of the Assistance Publique. The service is to be under the direction of the medical staff of the hospitals. Evidently Paris prefers to be in the front rather than in the rear of the procession, to lead rather than to be led. The day will come when it will be almost a good ground for a malpractice suit, if a case of fracture or dislocation has been treated without an examination by the X-rays. In connection with the above remarks, I remember an article in the "Wiener Klinische Wochenschrift", of February 17th, describing a method of locating foreign bodies in the eye, by means of the X-rays. The method described differs but slightly from the method that has been used in this country for the same purpose for some time.

An improvement on the method of Newman for the treatment of urethral stricture by electrolysis, is mentioned by the "Arch d'Elect. Med." for November, 1897. The improvement is devised by Debedat, and the article in question is written by him. He suggests the use of an electrode slightly different from that commonly used in that it is insulated from the urethra entirely, with the exception of a small portion at the olivery extremity; the method of application is also somewhat different, for he passes the electrode through the stricture before closing the electrical circuit; the electrode is then connected to the source of e. m. f., and upon withdrawal the electrolytic action is secured directly upon the stricture and nowhere else. He reports the successful use of his method in a number of cases and gives careful data of two of them; he finds that no case so treated had to suffer any further surgical interference and thinks that in a large number of cases this may be the method of election.

The meeting of the Chicago Medical Society for March was devoted to the discussion of cholelithiasis, several gentlemen giving their results of attempts to skiagraph gall stones; Drs. Bevan, Schmidt, and McArthur had tried, with the following results:

Dr. Schmidt's experiment was made with the gall stones in a normal salt solution so arranged that the rays would pass through about three inches of the solution; the shadows of the gall stones were but little darker than the solution. Dr. McArthur tried comparative exposures of gall stones and other concretions, and found that the gall stones cast very faint shadows as compared with other stones: Dr. Bevan embedded the gall stones together with lead, renal, and vessicle calculi in liver so arranged that the rays would penetrate from two to eight inches of tissue before striking the plate; he found that while the lead cast a very clear shadow and the other concretions cast quite distinct shadows, the gall stones, even those of good size and high specific gravity, cast shadows that were almost imperceptible; he concluded that the same stones in the living body would not have cast any shadow that could have been identified, owing to the movements of the body during respiration. The proceedings are reported at some length in the "Philadelphia Medical Journel" for March 19th.

The "Deutsche Medicinische Wochenschrift," for February 17th, contains an article by Carl Beck on the "Diagnostic Significance of the Roentgen Rays in cases of Arterio-Sclerosis." Beck presents radiographs of a case showing shadows of the radial and inter-osseal arteries on both sides, while the arteries of the head and neck and the aorta gave no radiographic appearance of thickening, thus confirming the appearances found in the temporal and facial arteries upon operation, and suggesting that this may be a good method of determining the extent of arterio-sclerosis. The above abstract is from the "Philadelphia Medical Journal."

The same journal contains an article by Dr. G. Betton Massey on "The Radical Cure of Malignant Disease by the Cataphoric diffusion of Mercury from Cold Electrodes, with Details of late improvements in the Author's Method". The article reports three cases, making in addition to the eight already reported by the same author, eleven in all. It is hardly fair to consider the method of treatment as a "cure", for the reason that no case has gone more than a year since the treatment; yet the results thus far reported are certainly encouraging and should lead to a more extended trial of the treatment suggested. The special electrodes used and designed by the doctor are illustrated in the journal quoted and the particulars of the method well described. A hollow gold electrode is the one now used, and the mercury is allowed to fill the tube, after it has been thrust into the tissue to be operated upon; a current of from 800 to 1500 milliamperes is recommended, the operation being done, of course, under a general anesthetic. There is considerable reaction to the treatment, which increases as the amount of cancerous tissue is lessened, but the pain is never intense. A selective action of the mercury is noted by the doctor, who states that the healthy tissue is not affected by the treatment.

The cases reported are certainly very remarkable in that they were all inoperable cancer.

The "Journal of Electro-Therapeutics" for March contains several articles of some interest. The question as to the nature of the causes of the increase in the effect of certain drugs, as for instance mercury, potassium iodide, etc., produced by the passage of a current, is discussed by Dr. F. M. Frazer at some length and with a good deal more clearness than is usually the case when physical problems are treated by the medical practitioner. The conclusion seems to be that the increased effect is due to the fact that the drug is acting in a nascent condition, owing to the splitting up of the molecules by the current, and as is well known, the action of a drug in its nascent state is greater than the action in the ordinary state. Dr. Clara E. Gary reported three cases of general pelvic disturbances which she had treated and cured by electricity, in one or more of its various forms; the results were good and they were average cases that may be met with and treated almost any day by the general practitioner. One had suffered three operations and the others had been advised to seek surgical interferance. The same journal contains a translation of the article from the "Rev. Internat. d'Elect." by M. Giles, on the application of the methods used in the treatment of urethral strictures, to the strictures of the esaphagus. There seems to be nothing new in the method of treatment suggested other than the common sense changes that would occur in the modification of the one treatment to the esophagus. A number of very excellent cures are reported.

Some radiagraphs have been made in Paris, France, of a cadaver; the subject was first injected with a mixture of shellac dissolved in alcohol, carrying in suspension metallic powder,—the ordinary "bronze" powder answers very well. The resulting skiagraphs showed the arterial distribution remarkably well and are said to have cleared up some disputed points, though the points in dispute are not mentioned in the article.

Transmission

AN 110-MILE CALIFORNIA TRANSMISSION.

The most interesting development of the month has been the somewhat premature announcement in San Francisco papers, of the organization of a strong company for the purpose of effecting the electrical transmission of not less than 10,000 horse power from Blue Lakes City to San Francisco, a distance of 110 miles by the pole line surveys.This new company, which is destined to be the cynosure of the attention of the electrical engineering world in the very near future, is composed of the principal members of the California Exploration Company, under the presidency of Prince Poniatowski, and of the Blue Lakes Water Company, under the presidency of Mr. W. Frank Pierce. Prince Poniatowski is president of the new corporation and the company has been so fortunate as to secure the services of Dr. F. A. C. Perrine as its consulting electrical engineer. The money for the building of this noteworthy transmission has been secured and the active prosecution of its installation now only awaits the conclusion of a few final investigations into the commercial feasibility of the project.

Readers of the Journal of Electricity are familiar with the Blue Lakes and California Exploration Companies through the descriptions of their properties appearing in the Blue Lakes Edition" of the Journal in October last. Aside from the natural flow of the Mokelumne river, the Blue Lakes Water Company possesses a water system having a storage capacity of twenty-one thousand billion gallons which, considering the high head at which the water may be used (about 1040 feet), constitutes the most abundant water power to be found in the State of Caifornia. The amount of this power is in the neighborhood of 50,000 horse power and the cost of its develpment is estimated to be about $100.00 per horse power delivered in the pipe line. Its distance is 49 miles to Stockton, 51 miles to Sacramento, 97 miles to Oakland and, as stated, 110 miles to San Francisco, possessing in all a population of nearly 600,000.

The proposed transmission will possess features that, being without precident, will be both interesting and tartling. Hitherto the Bay of San Francisco has presented a barrier that has been believed to be impossible to any electric transmission into San Francisco, but acting under a suggestion of the engineering department of San Francisco office of the General Electric Company, the circuits will in all probability be brought across the bay by pole line rather than through submarine cable, as the pole line will permit the carrying of very high potentials at but a tithe of the cost of cables for carrying an equal amount of power.

ELECTRICITY IN THE SHOW BUSINESS.

There is hardly an exhibition now presented to the amusement loving public that does not possess some electrical feature of more or less importance and in some of them electricians are affordeded opportunities for bringing out exceedingly clever effects that are possible by no other agency. Of such a nature is the interesting exhibition now open on Market street, near Larkin street, San Francisco and known as "Around the World," the mechanical and electrical engineering features of which were all planned and executed by the students of the van der Naillen School of Engineering. The electrical portion of the exhibition was placed under the direction og Mr. A. R. Talamentas, one of the students of the electrical engineering course, to whom great credit is due for the exceptional genius and good workmanship displayed.

A PERMANENT POSITION WANTED.

A married man of exemplary habits and wide experience in the operation of steam and water power electric stations, desires a situation. He is fully competent to erect, and operate electric plants for every description of light and power service and desires a permanent location rather than high wages. He has had ten years' experience on the Pacific Coast, three of which were spent in high potential transmission service. Best of references.

Address: "C. H. R.," Care of F. G. Cartwright, 18 Second St., San Francisco.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity, Gas and Power.

OFFICIAL ORGAN OF THE PACIFIC COAST ELECTRIC TRANSMISSION ASSOCIATION.

Subscription Payable in Advance. Terms—Domestic, One Dollar per Year; Foreign, Two Dollars per Year.
Rates for Advertising on Application.

The trade supplied by the San Francisco News Company.

EDITED AND PUBLISHED BY GEO. P. LOW.

Business Office, 22 CLAY STREET
Telephone, Steiner 623.

Address all communications to
Editorial Rooms, 427 TENTH AVE

SAN FRANCISCO, CAL.

Entered as Second-class Matter at the San Francisco Postoffice

VOLUME V. APRIL, 1898. NUMBER 7

EDITORIAL.

THE LINING OF THE RAINLESS CLOUDS.

The general complaint which is going up from all sections of California over the scarcity of rain during the winter just ended finds official confirmation in the Bulletin of the United States Department of Agriculture, which reports that the drouth in California continues and that "the deficiency in rainfall is nearly one inch in the northern coast section; half an inch in the great coast valleys, decreasing southward, and about a quarter of an inch south of the Tehachapi * * * The continued absence of the late spring rains gives little hope of relief."

Continuing, the "Crop Bulletin" states that "Grain and hay have suffered severely and the outlook is discouraging. Stock is starving and horses can be bought in some localitites for $1.50. Sheep are perishing. Fruit is doing well, but as orchardists have not faced such a dry season before, the future is uncertain."

With such an extraordinary condition of climatic affairs confronting a state whose plenty is proverbial, it is a natural consequence that other interests should be threatened along with these which "have not faced such a dry season before." Among these will probably be the electric transmission interests, as present conditions indicate that the coming summer will be an unprecedentedly trying season to some of them in the matter of water supply, to overcome which heroic measures may have to be adopted. However unfortunate it may be that such exigencies are possible, it is well that the issues they present should be fairly met and squarely overcome, for they are factors in the result that must ultimately receive the judgment of the cold business precepts that hold absolute sway in the counting house of commercial feasibility. . The impartialty of this court of final resort is conceded and while it will take cognizance of the difficulty that will probably beset some electric transmission plants from the drouth, it will also recognize that the production of steam power will be attended with probably equal difficulties through the impending Hispano-American war, one of the results of which will be the cessation of the importation of coal.

Though the rain clouds have been conspicuous in California during the past winter by their absence, it is safe to say that, where ever they may be, their linings are silvery for transmission interests through a new line of business that the propective dry season is forcing upon the electrical fraternity. High load factors develop economy in operation whatever be the prime mover, and while the great orchard and vineyard districts of the State are threatened with a water famine through the scant supply for the irrigation systems, the lower strata of the vast valleys of California always contain unlimited supplies of water which is most economically brought to the surface by electric pumping stations operated from electric transmission lines. Hundreds of horse power in electric motors have already been sold this spring for this most desirable class of work—and the market has but just opened with the fixing of the belief in many localities that underground sources rather than the irrigation ditches, furnish the most trustworthy souce of the water supply upon which hangs the life thread of the limitless horticultural, viticultural an agricultural resources of the great Golden State.

HE WINS THE SECOND PPIZE TOO.

It is now several months since the awarding of a leathern medal of great rarity to Mr. Charles R. Lloyd for the sublimity of his mental acuteness in permitting evidence to be introduced under which a court of justice at San Bernardino was compelled to instruct the jury to the effect that the measurement of water power was a matter of individual opinion, rather than a definitely ascertainable fact. As a consequence the jury returned judgment against Mr. Lloyd for about $14,000.

As the time for the awarding of the second trophy approached, there appeared many aspirants for the distinguished honor of bearing it off, but it has transpired that the dark horse in the race was none other than Mr. Lloyd himself, and so valiantly did he execute his inborn part that now with the utmost graciousness does the "Journal" confer upon him the proud privilege of wearing the second trophy of the series. Like the first medal, the second prize too is a finished product of the tanner's art, but the workmanship upon it has given it a value involving some $20,000.

How Mr. Lloyd has come to be possessed of this new honor is being told and oft repeated at every rondavous of electrical and corporate nabobs. It seems, so the narative goes, that in anticipation of an adverse decision in the San Bernardino suit, the well known subject of this anecdote put every bit of his property out of his name so effectually that in the undiscerning eyes of the law he was a pauper indeed. Verily, though there were inviting places whereon to lay his physical head, leagally speaking he had no financial head which he might lay. And so it came to pass that the $14,000 judgement remained unsatisfied.

But the day of the annual meeting of the stockholders of the San Francisco Gas and Electric Company came and, as there was to be a gathering of the clans to celebrate the occasion, Mr. Lloyd hied himself to his resources and, after secluded consultation therewith, was duly qualified as the holder of a certificate for 200 shares of Gas and Electric stock, which of course, proved an open sesame to the joyful gathering. With unalloyed pleasure he entered the meeting, with unalloyed displeasure he departed for in truth, the one Lloyd had learned that the attorney of the San Bernardino plaintiffs had attached the 200 shares in satisfaction of the unpaid judgment. Presently a bond for $20,000 was forthcoming to release the stock and now, behold the leather medal, the second of the "Journal's" series of booby prizes, bedecks the veteran breast of Mr. Charles R. Lloyd.

AN INSTANCE OF ELECTRICAL VAGARY.

One further reference to the much-talked-of pair of Fresno eagles that were incinerated on the line of the San Joaquin Electric Company, may be pardoned in connection with a very interesting piece of information that has been received concerning the two owls that were killed on the line of the Power Development Company, of Bakersfield, Cal., in exactly the same manner as were the eagles; namely, by alighting on a 10,000-volt transmission line.

It will be remembered that the Fresno eagles were burned all but completely out of existence, there remaining only one skull and four claws with parts of legs from which the character of the birds could be identified. With the Bakersfield owls, however, the only evidence of physical injury to be found was the fact that both eyes of each bird had been put out. No other mark of injury of any nature was to be found on either bird. It is no wonder then that in referring to the two incidents, one is impressed with the vagary of high tension electricity which utterly annihilates in one instance and but snips out the spark of life in the next.

Visitors to the coming Electrical Exhibition soon to be held in Madison Square Garden, New York, will have the opportunity of seeing the interesting and gruesome relics of both the eagles and owls, as they will form conspicuous features in the "chamber of horrors" to be then shown.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

STEAM IN FUTURE CENTRAL STATIONS.

It has long been realized that the bringing of the steam engine to its present state of efficiency in operation and regulation was due to the introduction of the dynamo and the condition imposed by it necessitating a well regulated steam power of high and constant speed. The history of this development is admirably brought out in the current number of "The Engineering Magazine" in an article by Mr. Charles T. Child on "The Steam Engine and the Dynamo," and the one idea that stands out above the others there given is found in the observation that the steam turbine promises to drive dynamo designers to the consideration of the very highest speeds for their machines. Slow speed motors will probably ever embody advantages that will make them always the most desirable means for the conversion of electrical into mechanical power, and at the present time the almost universally accepted belief is that in slow speed generators are to be found the best practice attainable for direct connection to steam engine units, but the steam turbine bids fair to demand a return to the earlier days when, as the output of a dynamo is directly proportional to its speed, considerations as to first cost demanded that the dynamo be driven to its utmost speed capacity.

Well does the writer referred to observe that the remarkable efficiency of the steam impulse wheel, its extraordinary simplicity, and the high output of power per unit of weight secured by its use, make it the ideal machine for the conversion of thermal into mechanical energy and for dynamo driving, save for the one apparently insurmountable difficulty of its enormous speed of rotation, which is often as high as 30,000 revolutions per minute. Thus far, the unmanageable velocities encountered have forbidden the commercial extension of the method, though some combinations of steam turbine and dynamo are successfully working under commercial conditions. Hitherto no attempt has been made to design a dynamo for direct operation at the speed of the turbine, but the effort has been to reduce the speed, either by gearing or directly to that of the present type of dynamos. The analogy of the case of the dynamo and reciprocating engine twenty years ago seems to point to some compromise method. Certainly gearing will never be tolerated so long as there is the least hope of directly reducing the speed of the steam turbine. There appears to be good reason for thinking that compounding offers a solution of the difficulty and that speeds as low as 2,500 revolutions per minute may be had directly from a multiple wheel, multiple expansion turbine.

There appears then, two difficulties to be overcome before the operation of steam tubines and dynamos in direct connected units can become an accomplished fact, namely; the speed of the turbine must be reduced or, assuming that it is impracticable to build such high speed generators in alternating current types as will give sufficiently low periodicities to be available for use under present conditions, electrical advancement must be very great along the line of high frequency application to enable the utilization of the alternating currents that would be most readily adapted as the output of the new types of generators. The solution of one difficulty as presented would furnish that for the other, and the belief is not untenable that in a direction to that herein indicated will be found the most marked progress that is to be made during the next decade in the joint use of the steam engine and dynamo.

WANTED, A NAME.

If the origin of the term "underwriter," in an insurance sense, be accepted as precedent for the coining of analagus designations, the electrical fraternity would long since have become known in the commercial world as "under-bidders," or even as "profit-sharers" from its chronic characteristic of always underbidding the other fellow, or its ruthless sacrifices in their insane race for business. The fiercenes of competition in the electrical supply line, as well, in fact, as in all other lines of the electrical industry, is perhaps unappoached in any other branch of trade and so cut up is the business in some channels that it might tend to bring the participants to their senses if they could become to be known as a class referred to only in terms of ridicule.

But as to the origin of the term "underwriter," which is suggestive, Mr. Edward Niles, in a paper on "Special Agents" read before the last annual meeting of the Fire Underwriters' Association of the Pacific, pointed out that the name "underwriter" dates back to the first part of the present century. Up to 1824 insurance companies were not allowed to effect marine insurance, with the exception of the London and the Royal Exchange. The high rates charged by these two companies, which had the monopoly, forced the business into the hands of private persons, who were obliged to resort to a trick, in order to transact their business. These persons could not enter into an agreement jointly as a company, as such a proceeding would be illegal. So they met in Lloyd's coffee house in London, and when a merchant or ship-owner wished to insure his vessel or freight, these individuals subscribed or "wrote under" the policy of inurance the sum each would make himself liable for, in case the ship or cargo was lost.

Surely the conditions under which the marine insurance man of seventy odd years ago labored were hardly more onerous than those confronting the electrical salesman of to-day and as the familiar name of underwriter is now a commonplace, so may the future recognize by an equal familiarity some of the difficulties under which the toilers of the present labor.

PREACHING THE GOSPEL OF PROSPERITY.

"The American Economist" of March 25th presents in the form of a pictorial supplement an unique and interesting array of drawings and cartoons selected from the files of that paper for the past three yeas. The illustrations, several hundred in number, emphasize in a peculiarly forcible manner the strength of the doctrine of Protection as an active, living political issue, and also demonstrate with what vigor and aggressiveness this dotrine has been expounded by the American Protective Tariff League.

Literature.

Any Book Published Mailed upon Receipt of Price by The Journal of Electricity.

"A Pocket Dictionary of Electrical Words, Terms and Phrases," by Edwin J. Houston, Ph. D. Flexible binding, gilt edges, 945 pages, 3 1-2x6 1-4 inches. Published by The American Technical Book Company, 45 Vesey street, New York. Price: Leather, $3.00; Cloth, $2.50.

Any publication under the authorship of either Edwin J. Houston or of Messrs. Houston & Kennelly, bears the indelible imprint of originality, thoroughness and accuracy, and so universally is this fact recognized that to thousands of electrical readers the mere announcement of a new book under their authorship, either single or collectively, awakens the knowledge that that book is indispensible to every electrician, whether he be student, theorist or practitioner. Such, in brief, is the character of Houston's "Pocket Dictionary of Words, Terms and Phrases."

In the preparation of the supplementary matter for the fourth edition of "Houston's Dictionary of Words, Terms and Phrases," it was found that so rapid had been the growth of the art and its terminology, that the number of new words, terms and phrases greatly exceeded those in the original dictionary with its appendix. It was, therefore, necessary to collate the old material with the new and arange it alphabetically in order to avoid the incongruity which would exist in a second appendix which would outnumber the definitions in the last edition of the book. The necessity for economy in space led to the adoption of concise definitions, to the exclusion of all encyclopedic matter.

It is evident that, in the light of former experience gained from the preceding editions of the dictionary, the author decided to employ no cross-references in the Pocket Dictionary, and, therefore, to arrange the terms alphabetically in their natural order. There has thus been produced an epitomized edition of the original work, together with the new matter that has been added thereto. The Pocket Dictionary is therefore the separate publication of the fourth edition with its supplemental matter, in a convenient form for those who seek only brief definitions. All technical students, however, and those who wish to penetrate deeper into the science, will find it greatly to their advantage to obtain a copy of the complete fourth edition, the encyclopedic matter in which, with its system of cross-references, will enable them to gain material advantages.

A striking evidence of the certainly phenomenal advance that has been made in electrical applications during the last few years must be noted in the fact that the Pocket Dictionary contains over 6,000 new electrical words, terms and phrases that have come into use since 1894, the book containing definitions of about 1,000 different words and of about 15,000 different terms and phrases.

"The American Newspaper Annual." Published by N. W. Ayer & Son, Times building, Philadelphia. Cloth, 1054 pages, 6x9½ inches. Price, $5.00.

The science of advertising in periodicals has become a most exact one to those who have devoted years to its study, and of these, Messrs. N. W. Ayer & Son, and George P. Rowell & Company are perhaps the foremost in this country. Both of these concerns issue newspaper directories, and that of Messrs. Ayer & Son for 1898 is at hand.

The American Newspaper Annual for 1898 is, as its name indicates, a cyclopaedia of American journalism. In detail, it is a carefully prepared list of newspapers and periodicals published in the United States, Territories, and Dominion of Canada, with valuable information regarding their circulation, issue, date of establishment, political or other distinctive features, names of editors and publishers, and street addresses in cities of fifty thousand inhabitants and upward, together with the population of the counties and places in which the papers are published. It also contains a description of every place in the United States and Canada in which a newspaper is published, including railroad, telegraph, express and banking facilities, as well as the vote of States and counties at the Presidential election of 1896.

It is obvious that the labor attending the publication of a work of this class forms an item of great expense, necessitating a selling price that may seem excessive, but which the careful advertiser soon finds is not so. The Annual lists over 22,000 periodicals, and it is safe to say that probably less than one quarter of the newspaper advertisers in America have occasion to consult a newspaper directory for information concerning publications in practically all portions of the continent, which leads to the suggestion that it might be profitable (it certainly would be convenient to a majority of advertisers) to publish in addition to the Annual in its present form smaller editions of it that shall contain information by States, or even by sections of the country. The Californian, whether he be manufacturer or merchant, finds no profit in advertising in Eastern publications, hence he has no use for, and may not care to buy, a great book containing a mass of matter, but four-fifths of which pertains to his own section and is of interest. With the Eastern manufacturer whose goods reach every portion of the country and who advertises in papers in almost every town and city, the case is a different one, and the Annual in its present most comprehensive form is at once indispensible and of priceless value. But doubtless the publication of lower priced editions of the Annual for the different sections of the country, such as a New England edition, a Southern edition, a Middle States edition, a Mississippi Valley edition, a Pacific Coast edition and a Canadian edition, would be a duly appreciated convenience by the great majority of advertisers the country over.

A "Manual of Static Electricity in X-Ray and Therapeutic Uses," by S. H. Monell, M. D.; published by William Beverly Harison, New York City. Second edition, with appendix; royal octavo, 622 pages and 18 pages index; 21 illustrations; printed on heavy paper, large type. For sale in San Francisco by the "Emporium," price $6.00.

This is by no means an easy book about which to express an opinion for the reason that it has at the same time both many good and many bad features; it is to be commended and condemned. It is an easy task to express unqualified disapproval, but not such an easy task to moderate the condemnation to suit the good qualitiese that may be weeded out of the trash.

The book is divided into two parts; part first contains XL chapters, the contents of which are as follows: I, The Holtz Apparatus; II, Collected Opinions as to the Value of Static Electricity in Medicine; III, The Care of the Holtz Machine; IV, Therapeutic Mtheods; V, Platform Methods in General; VI, How to Regulate the Strength of a Static Application; VII, X-Ray Apparatus and Static Methods; VIII, X-Ray Apparatus and Crook's Tubes; IX, The Three Best Methods of operating Static Tubes with Large Holtz Machine; X, X-Ray Photography; XI, X-Ray Effects in General; XII, Electro-Physiology; XIII, The Therapeutics of Static Electricity; XIV, Rheumatic Diseases; XV, Chronic Gout and the Uric Acid Diathesis; XVI, Neuralgias and Neuritis; XVII, Neurasthenias; XVIII, Chronic Functional Nervous Diseases; XIX, Static Electricity in Hysteria; XX, Pain; XXI, Brain Fag and Insomnia; XXII, Remarks upon some of the Mistaken Ideas of Beginners, which Experience and Information Corrects; XXIII, Miscellaneous Conditions; XXIV, Heart Disease, Chronic Grief, and Weather Neuroses; XXV, The Value of Electro-Muscular and Nerve Stimulation in Training for Contests of Skill, Strength, Speed, Endurance, and Dexterity; XXVI, Headaches; XXVII, Special Therapeutic Effects; XXVIII, diseases of the

Skin; XXIX, Ditto; Continued; XXX, Chronic or Sub-Acute Inflammatory Conditions within the Thorax; XXXI, Morbid Mental States; XXXII, Chronic Cathexias; XXXIII, Tonic Effects in Various Conditions; XXXIV, Impaired Voice of Singers—Debilities of the Aged; XXXV, The Contra-Indications of Static Electricity; XXXVI, Paralytic Diseases; XXXVII Writers Cramp; XXXVIII, Miscellaneous Conditions; XXXIX, Ditto; XL, Static Electricity in Gynecology;

Part Two; I, Historical Therapeutics; II, General Remarks, Relating to Medical Electricity, by T. Cavallo, F. R. S., 1777; III, Clinical Cases treated by Static Electricity, 1776-77 and 1795; IV, Sundry Clinical Observations; V, The Past and Present Nature of Electricity the Same; VI, Improvements in Electrical Apparatus in 1789; VII, The Celebrated Guy's Hospital Reports; VIII, value of Static Electricity as a Remedial Agent in the treatment of Disease, by Golding Bird, M. D., A. M., F. R. S., etc.; IX, Continuation of Dr. Bird's Report; X, Continuation of Dr. Bird's Report; XI, The Guy's Hospital Reports of Hughes and Gull; XII, Continuation of Reports of Sir William Gull, M. D., D. C. L., F. R. S.; XIII, Ditto; XIV, Ditto; XV, Cases Treated by Dr. A. Arthuis, of Paris, in 1872-73; XVI, Ditto; XVII, The Moral Effect of the Static Machine, Considered as a Medical Apparatus.

A careful examination of the above chapter list will disclose the fact that there is a good deal of repetition and a large amount of matter that is not essential to the subject in question; the classification is bad; in fact, there is almost no classification at all and the same subject is often treated of in a dozen different places through the book. Some of the actual directions to those who are ignorant of the methods of handling an influence machine (generally and improperly called a "static machine") or of treating a patient by the high tension currents and static electrification for which it is intended, are excellent. The explanations and directions in these passages are clear, concise, intelligable and to the point; the illustrations, which are intended to elucidate the text, are far from what could be desired in many instances.

We certainly expected great things of this text book, hoping that it might be a radical improvement on the usual type of Medical text-book on things electrical; unfortunately this is not the case. The same old absurd jargon is found throughout the pages of the work under consideration, and the same utter absence of a technical knowledge is displayed, though the author employs a diction that would lead one to imagine he really thought his utterances were ex-cathedral. On almost every page of the book can be found the expression "static current;" will some one kindly give a definition of the phrase? What, in the name of the good English tongue is a "static current?" If memory serves and dictionaries do not lie; if all the men who have worked in electricity and written standard books on the subject—for instance such men as Faraday, Maxwell, Kelvin, Thimpson, Guillemin, et al., have not been grossly deceived or have not grossly fooled the world at large, the words "static" and "current" are diametrically opposed in their meaning; static, as the word signifies, is used to indicate a condition of electrification in which electricity is regarded as at rest, simply under strain, while kinetic electricity is the term used to include all forms of current phenomena. To speak of a "static current," then, is about as absurd as to call a locomotive a stationary engine! And yet this unfortunate expression has found its way into every text-book on electro-therapeutics that deals with the subject of influence machines or their phenomena, and will probably continue to appear for years to come.

Dr. Monell makes many statements that the unwary reader will be too apt to regard as accepted truths, simply from the manner in which they are stated; he evidently is one of the many people who can not tell the difference between what they know and what they only think they know. For instance, he makes the statement in the most positive terms that the oscillating currents developed by the disruptive discharge of an insulated and charged patient, or what he calls the "static spark," penetrate deeply into the tissues. This may be true, but he gives no proof of the fact and seems to accept it as axiomatic; if this should prove to be the case it will be a quite anomalous phenomenon, for we know that the higher the rateofperiodisity, the greater is the skin resistance—the less is the penetration of the current into the substance of the conductor. Another error, or expression of ignorance, may be found on page 70. The author here states that it "is a law in electrics that the potential inside a conductor has the same value as at any point on its surface." We would respectfully call the doctor's attention to another "law in electrics," to wit, that a charge always resides on the surface of a charged, insulated conductor, and would suggest the careful perusal of "Elementary Lessons in Electricity and Magnetism" by Sylvanus P. Thompson; or if his digestion will stand the richer food, Maxwell's Treatise on Electricity and Magnetism, a classic that is one of the world's greatest books.

From page 114 we quote the following: "Moreover, none of the alleged injurious effects of x-rays, reported hastily and with more or less sensation, are caused by the static current." We should like to call the doctor's attention to a letter from Elihu Thomson in "The Electrical Engineer," January 6, 1897, in which the above quotation from the work under discussion was answered before it was written! To enumerate more of the errors of ignorance which dot the pages of this book, would be too much of a task; suffice it that from an electrical standpoint the statements made by the author are in many instances utterly without foundation and absurd.

Another fault to be found with the work, is the general tone of much that is said in regard to the work of others; the conceit of a man who can write a book of over six hundred pages, mostly given up to the statement that he is the only man who knows it all, and that if the poor practitioner wants to learn how to use "static currents" he must come to "My School," this amount of conceit, we fancy can better be imagined than described!

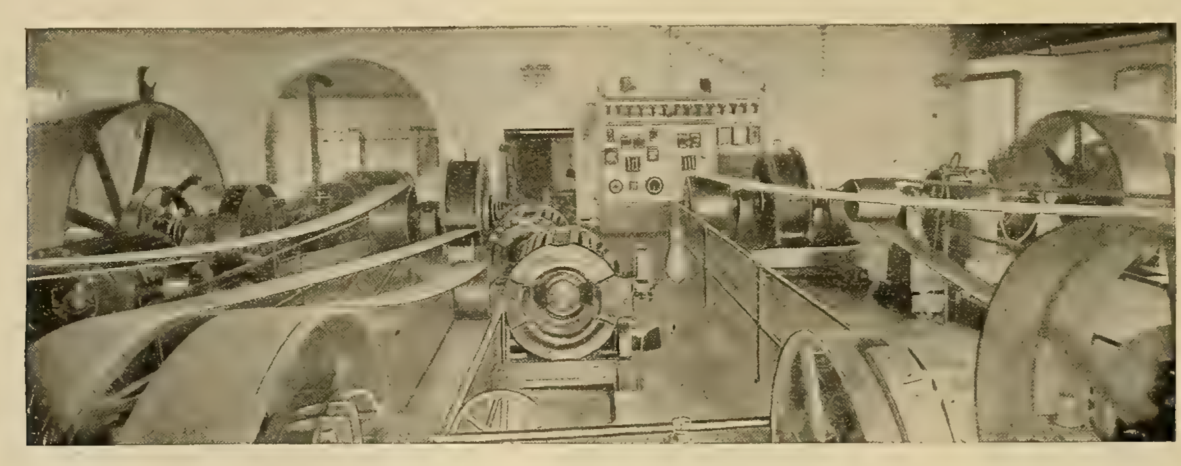
If the book were edited by someone with a tehnical knowledge of electricity, condensed to about two hundred pages, and much of the conceit eliminated from it, it would be an excellent text-book, for it certainly does contain some matter that may be of value to one in search of information in regard to the clinical necessities in the use of an influence machine. The collected cases and the clear method of describing the treatment in each case, are features to be highly commended. As this is about the only text-book giving any data in regard to the influence machine, it will be found of value to users of that form of electrical apparatus.

Philip Mills Jones, M. D.

Illumination

ELECTRIC POWER WITH LIGHTING AS AN ADJUNCT.

A GREAT number of central stations are now using that modification of the single phase system, known as the monocyclic system, by which current may be supplied to both lamps and motors at the same time from their alternating generators. This system was introduced at a time when the question of extending the area of operation began to force itself upon the attention of central station managers using either the single phase alternating or the direct current system of supply. With the first named the question of distance presented no difficulty, but motors could not be operated successfully by it; with the direct current system, while the motors presented no difficulty, the area of operation was limited. With the newer system it was found that both arc and incandescent lamps, as well as induction motors could be supplied from the same alternator, the first named operating directly from the ordinary two wire single phase circuits, the motors merely requiring a third wire to give a displaced voltage. Opeation of the monocyclic system has evidently proved satisfactory, as the installation about to be described, and which is but one of many, demonstrates.



INTERIOR OF THE MIDDLETOWN, O., STATION.

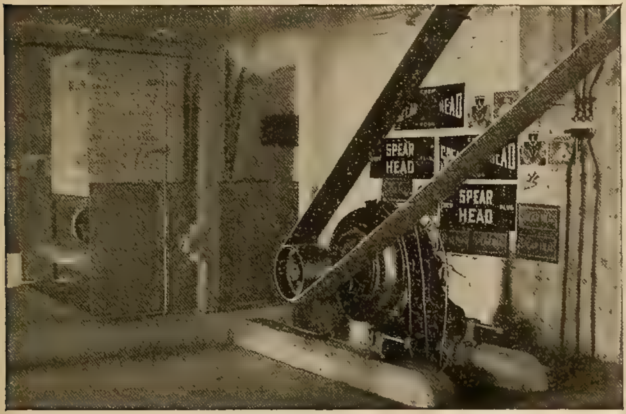
One of the interesting examples of the introduction of the monocyclic system into a direct current station, allowing the area of its operaion to take a wide extension, exists at Middletown, Ohio, where Mr. E. F. McKnight, the President and General Manager of the Middletown Electric Light and Power Company has recently found it necessary to increase the monocyclic capacity of his plant to meet the increased call upon his station. In addition to the arc and incandescent lighting usual in towns of the size of Middletown, certain factories under progressive managers have adopted electricity in place of steam and the motor load on the station already far exceeds the lighting load.

The station fronts on the Miami and Erie Canal, having the tracks of the M. & C. Railroad immediately behind it. It is 65 feet wide and 115 feet long. Steam is supplied from two boilers, to one 450 compound condensing engine, and one 300 h. p. condensing engine. The generating plant consists of two General Electric 12-pole, 150-kilowatt, 1040-volt, 600-revolution monocyclic generators excited by two 1 1-2 kw. exciters; three 50-light Thomson-Houston series are dynamos and one G. E. 100 horse power 500-volt direct current generator, all driven from countershafting furnished with the necessary friction clutches.

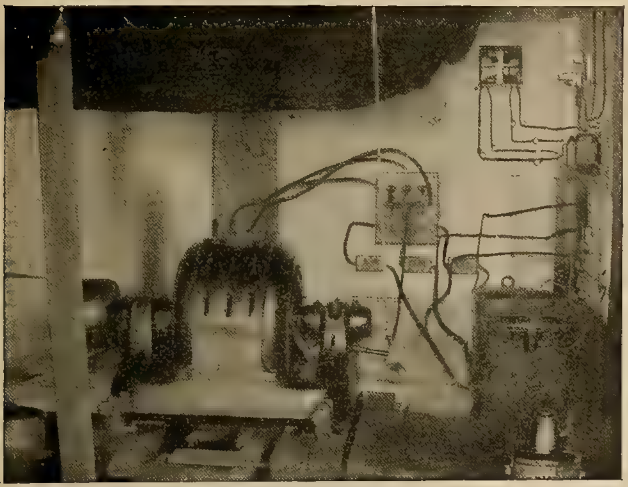
The 500 volt machine is used exclusively to furnish direct current to several small motor plants throughout the city; the arc machines operate 112 city arc lamps.

The motor load on the monocyclic machines runs up to within a short limit of their capacity. The factory of the Miami Cycle and Manufacturing Co., a little over a mile away from the station, takes 200 horse power when its motors are running at their rated capacity, and considerably in excess of this under usual working conditions. This company manufactures the well-known Raycle, and 1200 o these wheels are built weekly, giving employment to 600 hands. The current is received in the factory in six 40 h. p., one 20 h. p. and two 10 h. p. transformers, reducing the pressure to 115 volts. The motor circuits run from the 40 h. p. transformers, the lighting circuits from the three of smaller capacity, and all the current is measured in a recording ing wattmeter, connected on the primary circuit. The motor equipment consists in all of ten General Electric induction motors, 3 of 20 h. p. in the machine shop driving 88 machines, one of 10 h. p. in the drill and pattern room driving 29 machines, another of 10 h. p.

driving the machinery in the frame department, three of 30 h. p. in the polishing room—two for the polishers and one for the 48 inch exhaust fan; one of 5 h. p. driving two plating dynamos in the plating room, and another of similar capacity operating a number of small machines in the assembling room, as well as a three ton elevator. The incandescent lights in the factory number 750, of which during the rush season almost all are lighted.



MOTOR NO. 1 IN THE FACTORY OF THE P. J. SORG COMPANY.

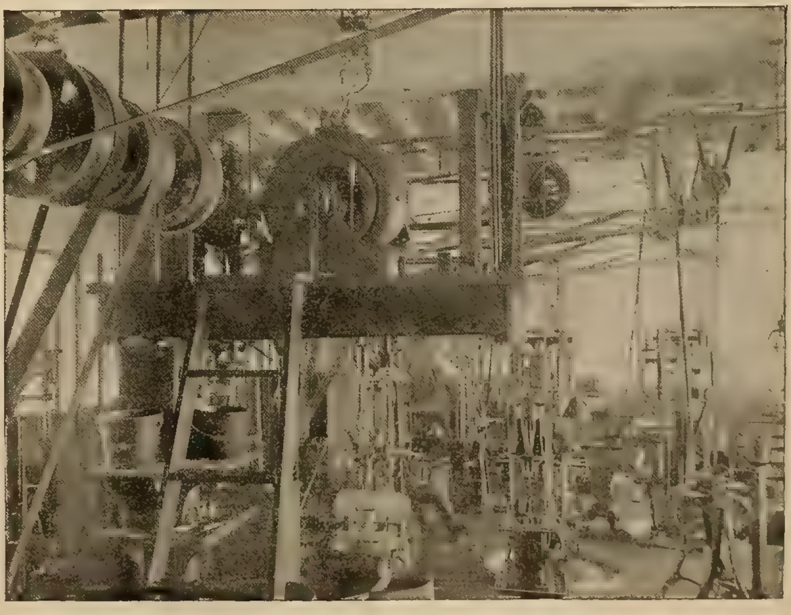


MOTOR NO. 2 IN THE FACTORY OF THE P. J. SORG COMPANY.

In addition to the Cycle Factory, Mr. McKnight furnishes power to the tobacco factory of the P. J. Sorg Company, in which two departments are already equipped, each with a G. E. 30 horse power induction motor. The first motor is the smoking tobacco department, on the first floor, and is bolted to shafting operating on the three floors above, 3 Caldwell pickers, 1 cutter, 2 granulators and 2 dust machines. Motor No. 2 is on the sixth floor, and is shown with the transformer and the meter, to which the primaries from the station are connected. From this point secondaries are carried to Motor No. 1 in the smoking tobacco department distant about 500 feet, and the lights in the different departments being tapped off before the motor is reached. Motor No. 2 drives two 7 1-2 inch rotary fans, used to dry all the tobacco, and also operates a five-ton elevator. The capacity of the drying department is 100,000 pounds of tobacco daily.

The benefits of electric drive by induction motors are, perhaps, nowhere so forcibly demonstrated as in these two installations. In the cycle factory the constant speed of the machinery, the absence of vibration and the power of the motors to respond to calls reaching as high as fifty per cent over their rated capacity, have enabled the manufacturers to give to every part of their wheels a perfect finish, as well as to greatly increase the output. In the tobacco factory the steady rate at which the tobacco passes through the dryers gives it a uniform cure. Previously the speed being variable, the tobacco would dry in spots only, and a second handling was almost always necessary. According to the foreman, the motor "saves him lots of time."

The incandescent lights in the town already wired number 3800; of these 750 are in the cycle factory, 100 are in the tobacco factory; 650 are in the opera house and 2300 in other parts of the town. These lamps burn with absolutely no interference from change in the motor load; in fact, the entire motor load may be thrown on or off without in the least affecting the burning of the lamps, the presence of the motor load being usually determined by reference to the ammeter. The monocyclic machines operate with almost perfect regulation, requiring little or no attention to maintain the constant potential at all times.



DRILL ROOM, MIAMI CYCLE & MFG. CO.

Personal

Mr. Zentaro Iijima, the Tokyo representative of the Wagner Electric Manufacturing Company, was a recent visitor to San Francisco.

Mr. Theo. Hofiman, general manager of the Hawaiian Electric Company, was in San Francisco recently purchasing additional station apparatus. He is visiting Eastern cities before returning to Honolulu.

Mr. E. C. Jones, chief engineer of the San Francisco Gas and

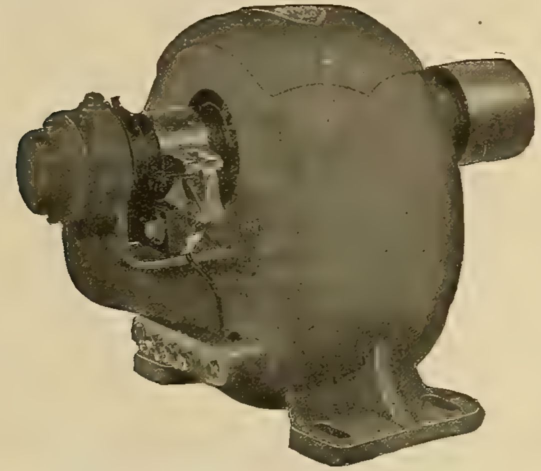
Electric Company, is spending the month at Coronado, Cal., in quest of rest and recreation.

Dr. Thomas Addison, Manager for the Pacific Coast District of the General Electric Company, is in New York and will not return to San Francisco before May 1st.

Prof. A. Van der Naillen and wife have gone to Europe where six months or more will be spent in touring through England, France, Belgium and Italy. The features of the various electrical engineering schools of these countries will be closely studied by the Professor with the view of improving, if possible, the electrical department of the Van der Naillen School of Engineering.

Mr. H. H. Sinclair, vice president and general manager of the Southern California Power Company, returned from the East on the 19th inst., after having succeeded fully in financing the affairs of the Southern California Power Company. Work on the 80-mile, 33,000-volt installation is progressing rapidly and without doubt the company will be able to deliver power in Los Angeles during September next.

Mr. I. Fujioka, Instructor of Electrical Engineering of the Imperial University of Japan and Consulting Engineer for the Tokyo Electric Light Company, has been granted a two years' leave of absence from home and is now making a tour of the world for the purpose of personally studying the most recent advances in electrical applications. Mr. Fujioka is one of the best informed electrical engineers in Japan.



DIRECT CURRENT STATIONARY MOTOR—TYPE "C A" 1 H. P.

Dr. F. A. C. Perrine has been appointed consulting electrical engineer of the newly organized Standard Electric Company of California for the proposed electric power transmission from Blue Lakes City to San Francisco, in consequence of which he has applied for a two years' leave of absence from the active work of the chair of professor of electrical engineering of the Leland Stanford, Junior, University. No more worthy appointment could have been made and news of it will be received the country over with the satisfaction of the knowledge that in Dr. Perrine's selection the transmission company has secured the services of one of the best electrical engineers to be found in the American profession.

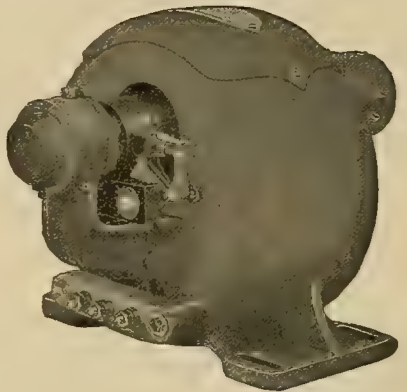
Mr. Clement A. Copeland, of Los Angeles, has been appointed Assistant Professor of Electrical Engineering of the Leland Stanford Junior University and will, during Dr. Perrine's leave of absence, take charge of the work of the department under the general direction of Dr. Perrine. Mr. Copeland entered with the "Pioneer Class" of Stanford from San Diego, making electrical engineering his major subject. This department at that time not being fully developed, on the advice of his professors he went to Cornell University, where he graduated with the class of 1896 in electrical engineering, since which time he has been engaged in electrical work. He stands very high as a practical electrician, and has in addition a thorough knowledge of electrical theory and mathematical physics.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

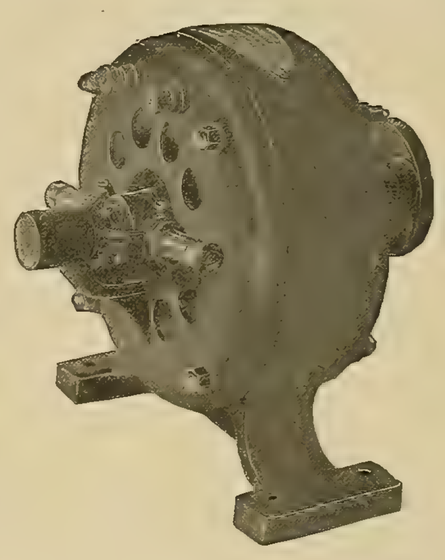
A NEW LINE OF SMALL MOTORS.

The General Electric Company announces in a recent bulletin a new line of well designed and thoroughly constructed direct current motors of small capacity adapted to the direct application of power to small machines of all kinds. They have been given the designation of "Type C A" and in their design the production of an efficient motor, sufficiently light and compact to allow of installation in cases where space is limited and absolutely rigied support unobtainable has been kept constantly in view. A magnetic circuit, therefore, entirely of laminated iron has been adopted and greater lightness and compactness is thus secured than would have been possible with cast iron. Furthermore, by the use of laminated iron a uniform magnetic circuit is insured.



DIRECT CURRENT STATIONARY MOTOR—TYPE ½ H. P.

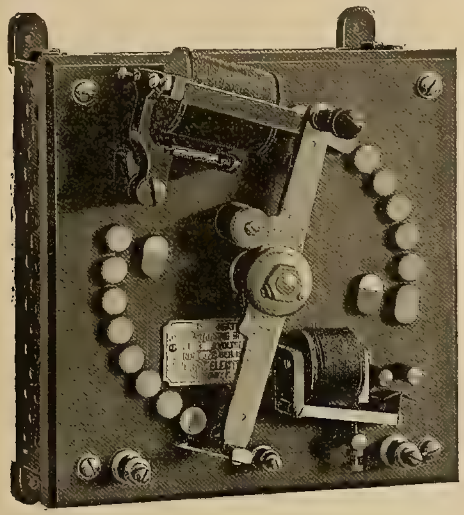
High grade material is used exclusively throughout these motors and the workmanship is the best. The construction of the armature, commutator and field coils follows closely that in the standard General Electric railway motors. Indeed every feature of excellence of the latter has been retained in the "C A" type. The laminated armature core is toothed and wound with the Eickemeyer type of coil. The leads from the armature are soldered directly into slots in the



DIRECT CURRENT STATIONARY MOTOR—¾ H. P.

segments and the field coils are thoroughly taped and mounted on laminated pole pieces. The armature can be withdrawn after taking off the pulley end bearing, and the field coils removed through an opening in the frame. In the larger machines the shaft is mounted on two similar swivel bearings each self oiling. The brush holders are adjustable radially, and may be revolved around the commutator if required. The neutral point is very wide, however, and no adustment of the brush holder is necessary. These motors are enclosed and thoroughly protected from mechanical injury, but thorough ventilation is provided by holes in the bottom of the case and around the commutator end of the armature. Should these motors be used in places where flying dust necessitates extra protection, the commutator and brush holders may also be encased.

The speeds are lower than usual with motors of small capacity and better provision for overload is thus given and losses are not so great. The regulation, efficiency and disposition of the material in the "C A" motors also combine to give them a continued high economy. Heating tests show that they will run continuously with but slight increase in temperature, and even with a momentary overload of 100 per cent little or no sparking is noticeable. In cases where a number of these motors are required to meet special conditions, the standard construction and wiring is susceptible of modification.



AUTOMATIC MOTOR STARTING RHEOSTAT.

No rails are necessary with this motor. The belt is tightened by moving the motor on the lag screws, which pass through elongated holes in the feet of the frame and hold the motor in place.

One feature of advantage which this motor has over others is the possibility of placing it in almost any position with no greater change than the turning of the bearings to suit the position selected. The "C A" motor may be installed on the floor or be suspended from the ceiling or be set on a shelf or attached to a wall. In every case the oil cellar is at the bottom of the bearing.

The 1 h. p. and ½ h. p. "C A" motors are designed for 115, 230 and 500 volt circuits, the ⅛ h. p. are 115 volt circuits. The floor space for the first named is only 22½ in. by 16 1-2 in. and for the 1-2 h. p. motor 18 3-4 in. by 13 in. The motors are finished in black with brush holders and small parts nickeled and polished.

For use with the two larger sizes a new type of rheostat has been developed. It is provided with an automatic switch which breaks the circuit in case of overload and effectually protects the motor armature. The smaller sizes are series wound and require no rheostat.

"The Journal of Electricity arrives in good order and it is a genuine pleasure to peruse its well-edited pages," writes Mr. J. H. Klieser, of Unga, Alaska.

NOVELTIES IN INCANDESCENT LAMPS.

The Brooks-Follis Electric Corporation is to be congratulated upon securing the order for the first installation of 220-volt lamps in San Francisco, namely, those to be used in the new and complete plant installed by W. R. Hearst in the new "Examiner" building, corner Market and Third streets.

The 220-volt type of incandescent lamps is made in voltages ranging from 200 to 250 volts. The 16 and 25 candle power lamp is 5½ inches long over all and the 32 candle lamp is 5⅝ inches long over all. The diameter of the 16 and 25 candle power lamps is 2½ inches and of the 32 candle lamp is 2⅞ inches.

Coiled and anchored filaments are used permitting the use of the lamp in any position without drooping and distortion of the filament. All lamps of this type are also furnished with a glass shield being mounted between the leading-in wires, preventing any possibility whatever of shoet-circuiting at this plant, which is a difficulty liable to occur when this precaution is not used. The Brooks-Follis Electric Corporation is prepared to fill orders for this type of lamp on short notice.

In this connection it may be well to call attention to the immense stock of lamps carried, it being probably the largest west of Chicago. At no time is this stock permitted to run below 50,000 lamps, if it can possibly be avoided, and it often runs up above 75,000 lamps. This feature places them in a remarkably good position to fill all orders with dispatch, which is quite a feature when quick delivery is imperative.

Attention is also called to the Fostoria Duplex Lamp, for which four claims are made:

First. That by the use of the incorporated switch, the candle power of the lamp can be doubled at will and turned back to normal candle power at the pleasure of the user.

Second. That if burned at ordinary candle power, using each filament separately, it will last twice as long again as any lamp now on the American market and from the excellent construction of the filament the globe will not blacken.

Third: That it can be used in all standard bases without any changes, expense or inconvenience.

Fourth: That, both price and efficiency considered, it is by far the most economical lamp yet brought out. The lamp has demonstrated its commercial value fully and they are selling remarkably fast. ......

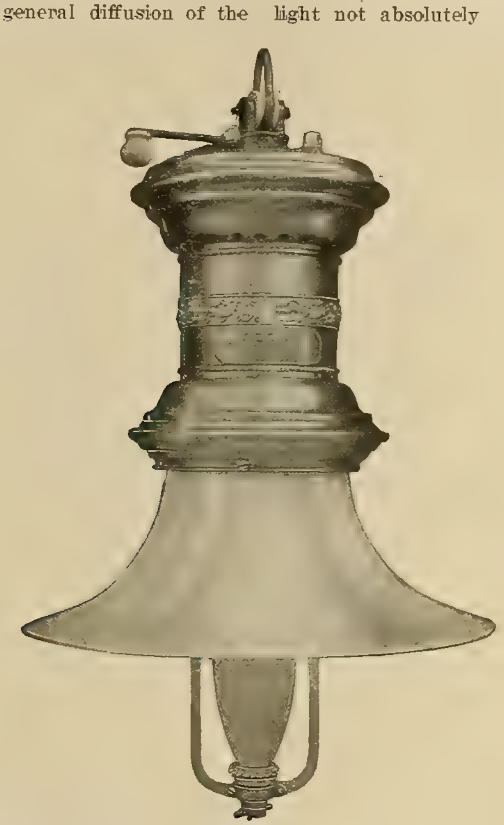
WHAT IS "KIP?"

The catchy "Kip" advertisement appearing elsewhere in this issue is bound to excite both mystery and admiration in the mind of the reader,—mystermy as to what the "three new things indispensible to every electrician, every fixture house and every central station," can possibly be. The feeling of admiration experienced by the reader is due to the realization that the advertiser's art has devised a novelty that excites the curiosity and demands attention. If there is something new abroad in the land that is indispensible to electricians, fixture men and central stations, all become eager to know just what those "three new things" are. ......

It violates no confidence to state that these "three new things" are chemical preperations which are invaluable alike to central station men and to patrons of electric lighting companies. Furthermore, as the advertisement states, the names of these new chemical compounds are "Karsline," "Inline," and "Playtone." Just what they are, what they will do, and how to use them will be made clear on application by mail to the Pacific Electric Company, 120 Main street, La Crosse, Wis., whose tasty folder on the subject is filled with interest.

THE NEW "G. E." ENCLOSED ARC LAMP.

A modification of its enclosed arc lamp has recently been perfected by the General Electric Company, which, while preserving the essential features of its well known direct and alternating current lamps, with enclosed arcs, substitutes a flared porcelain reflector for the outer globe. The mechanism of the lamp is similar to that of the standard enclosed arc lamps, but the use of the reflector instead of the globe, allows a large amount of light, which, otherwise, would be absorbed in the outer globe, to be thrown down by the reflector and thus utilized. Calculating this absorption of light at from ten to thirty per cent, the single globe lamp allows of the utilization of just so much of the total light from the arc, as well as that which is reflected. In cases in which the direct light from the arc is not objectionable and a general diffusion of the light not absolutely desirable, such as in cafes, hotels, restaurants, etc., the single globe is peculiarly adapted.



In designing the lower part of the frame, care has been taken to render it both light and delicate and yet sufficiently rigid to withstand ordinary usage, without interfering to any extent with the passage of the light or casting heavy shadows. It is highly nickled and thus, during the day time when the light is not needed, the ornamental appearance of the lamp is not detracted from. The inside of the porcelain shade is highly polished and gives a good reflecting surface. It is interchangeable and can be used with either direct or alternating globe enclosed arc lamps. By an arrangement of the lower rim of the cover of the mechanism, the reflector may be substituted for the outer globe of the double enclosed arc lamps. As in the direct current double globe lamps, a simple adjusting coil allows of the use of 5, 4½ or 4 amperes. By using a reflector instead of the globe a very satisfactory light may be obtained from this lamp with a current of only four amperes. A reactive coil in the alternating lamps, allows of adjustment for any line voltage between 100 and 120 volts and frequencies of 60and 125 cycles.

The economy in carbons is the same as that obtained in the double globe lamps, and in addition the lowering of an outer globe is done away with. The globe in which the arc is enclosed is protected by wire netting.

TABLE OF CONTENTS.

Illustrated articles are indicated by an asterisk (*)

*Alternate Current Workings, by Donald H. Fry.....125

Mining

Electricity in Mining.................................131

Transportation

*Details of the Mount Lowe Railway 130

Electro-Therapeuty

Recent Uses of Electricity in Medicine by Philip Mills Jones. M D... 132

Transmission

An 110-Mill California Transmission.. 134

Editorial

An Instance of Electrical Vagary....... 136
He Wins the Second Prize Too.......................135
The Lining of the Rainless Clouds...................135

Passing Comment

Preaching the Gospel of Prosperity 137
Steam in Future Central Stations 136
Wanted, a Name...137

Literature

"A Pocket Dictionary of Electrical Words, Terms and Phrases,"by Edwin J. Houston, Ph. D 137
"The American Newspaper Annual"......... 138
"A Manual of Static Electricity in X-Ray and Therapeutic Uses," by S. H. Monell, M. D 138

Illumination

*Electric Power With Lighting as an Adjunct........140

Personal

Personal........ 141

Industrial

*A New Line of Small Moters 142
What is "Kip?"......................... 143

The Westinghouse Electrictric and Manufacturing Company has just opened a new branch office at Austin, Texas. Mr. J. E. Johnson will have charge of the office and of the further extension of Westinghouse business in the Southwest. The large contracts which this Company has been handling in Mexico and the Texas region have led to the establishment of this new center of electrical trade.

The Journal of Electricity

Vol. V. MAY, 1898. No. 8

The Yuba-Marysville Transmission.

JUST one hundred and twenty-five days, or four moths and five days, elapsed from November 15th, 1897, when the Yuba Power Company begun work on the electric transmission about to be described, until March 21st, 1898, when the installation was placed in operation, and the work accomplished during that brief period included the entire rebuilding of the thirty odd miles of water system; the survey, location and clearing of the power house, pole line, two sub-stations, and the city distribution for over five thousand lights, in addition to the erection of all the hydraulic and electrical equipments of the plant. In no case was thoroughness and stability sacrificed to gain time, and the Yuba-Marysville transmission holds the well-earned distinction of having been the quickest installation of the kind ever accomplished.

Fifty years ago the Yuba River found no barrier in flowing along its natural course, but hydraulic mining long since shoaled the stream until now hundreds of thousands of acres of the fine farming lands of the surrounding counties would be innundated each year were it not for the great levees than have been thrown up to confine the river. Indeed where the Yuba was a few rods wide in the '50s, it has a width in some places of two or three miles at present, and on the low lands it pursues its sluggish, muddy way over a shallow, silty course to a junction with the Sacramento. After seeing the immeasurable quantities of soil and slickens that are deposited along the rivers of some of the valleys of California, one does not further wonder what has become of the earth which constituted the mountains that the early miners washed down and apparently removed from off the face of nature.

It is along one of the levees of the Yuba river that the road from Marysville to the power house of the Yuba Power Company follows for the first five miles of its route, then another five miles through an open country brings one to the foothills where the real beauty of the drive begins and this beauty grows upon one with ever heightening interest as the elevation increases. California was in all its spring-time glory when we went over the Yuba Transmission and the trip, though early in April, was a prolonged May-day outing. The mountain sward was as green and trim as any lawn; the oaks cast inviting shades and the luxurient wild flowers made the country so delightful that the twenty-two mile drive sped quickly. The road follows the pole line for perhaps two thirds of the way, for, while the country thoroughfare follows

The "Inverted Siphon" Crossing Dry Creek.

along the easiest practicable grades, the pole line takes a more direct route as is evidenced in the fact that its length is nearly four miles longer than that of the pole line.

The Pole Line.

The pole line is of a very substantial type of construction, being of round timber, specially selected for the Yuba transmission. The poles vary from thirty to forty feet in length according to location, and measure 12 inches at the butt by seven inches at the top. The kind of wood best suited for poles has long been an open question, but the concensus of opinion points to about an equal choice between cedar and spruce. For this reason, both varieties were used in the Yuba pole line in equal quantities, in fact cedar and spruce poles alternate on the line so that their respective qualifications, under equal conditions of service, may be determined. The butts of the poles are tarred and one sixth of the pole length is in the ground. The poles are set 120 feet apart, or 44 to the mile, and inverted "T" stubs are used for guying at all corners or bends in the line. A right of way 100 feet wide has been cleared through the wooded portions of the route of the pole line, amounting probably to less than one-half its length, the remaining portion being over open prairie or farming lands.

How the Transmission Crosses Dry Creek.

The construction of the pole line embodies all the best features of most improved practices in transmission work. Four-pin, pine cross arms measuring 3x4 inches by 5 feet are used, and these are gained into the poles, iron-braced, and painted with P. & B. insulating and waterproof paint. A single four wire, two phase circuit of No. 6 medium hard drawn copper of Roebling manufacture extends from the power house to the sub-station at Marysville, a distance of 18 1-2 miles by the pole line, while a second similar circuit is independently carried from the power house to the sub-station in Brown's Valley, 7 1-4 miles distant. These two, two phase circuits, consisting of eight wires, run along the main pole line to the "Christmas tree," as the corner intersection pole with its 32 power insulators and 12 telephone insulators, is called. Thence, the main line continues on to Marysville and the Brown's Valley circuit is taken up to the sub-station in the Webb Mine over a pole line that is identical in its features of construction and materials with the main line. The "Christmas tree" is six and a half miles distant from the power house, hence the branch line extending to Brown's Valley has a length of three-fourths miles. The four power cross arms on the "tree" are boxed in double and each carry eight "Locke" triple petticoat glass insulators measuring 5 1-2 inches across the base and weighing 5 lbs. each, while the telephone cross arms, placed five feet below the lower power cross arm, each carry six "Locke" glass petticoat insulators, all as shown in the illustration on page 1460. The telephone line is of No. 12, B. & S. gauge bi-metallic wire, transposed every tenth pole. The telephone cross arms carry the regular long distance wies of the Sunset Telephone and Telegraph Company as well as the private line of the Yuba Power Company.

A Characteristic View of the Pole Line.

The insulators and the method of mounting them are deserving of special consideration as they are believed to embody the results of the experiences of California transmissions regarding the line for high potential work. The Yuba Power Company is operating a line potential of 16,700 volts, which is the highest pressure of any California transmission up to the present, that between Newcastle and Sacramento, at a trifle under 16,000 volts, being the next highest. To support the Yuba lines, it was determined to use "Locke" glass insulators of the type defined, on one-half inch steel-locust pins, fitted with the "Locke" porcelain base, the latter being given a coat of P. & B. paint at the time of painting the cross arm. The line wires are secured to the sides of the insulators by standard Western Union long ties, and the power lines are not transposed, except a half-twist in the Brown's Valley line at a point midway between the power house and the "Christmas tree." The Brown's Valley circuit has a capacity of 750 kw. at a line loss of four per cent., and the Marysville circuit has an equal capacity but with a line loss of ten per cent.

At the Power House.

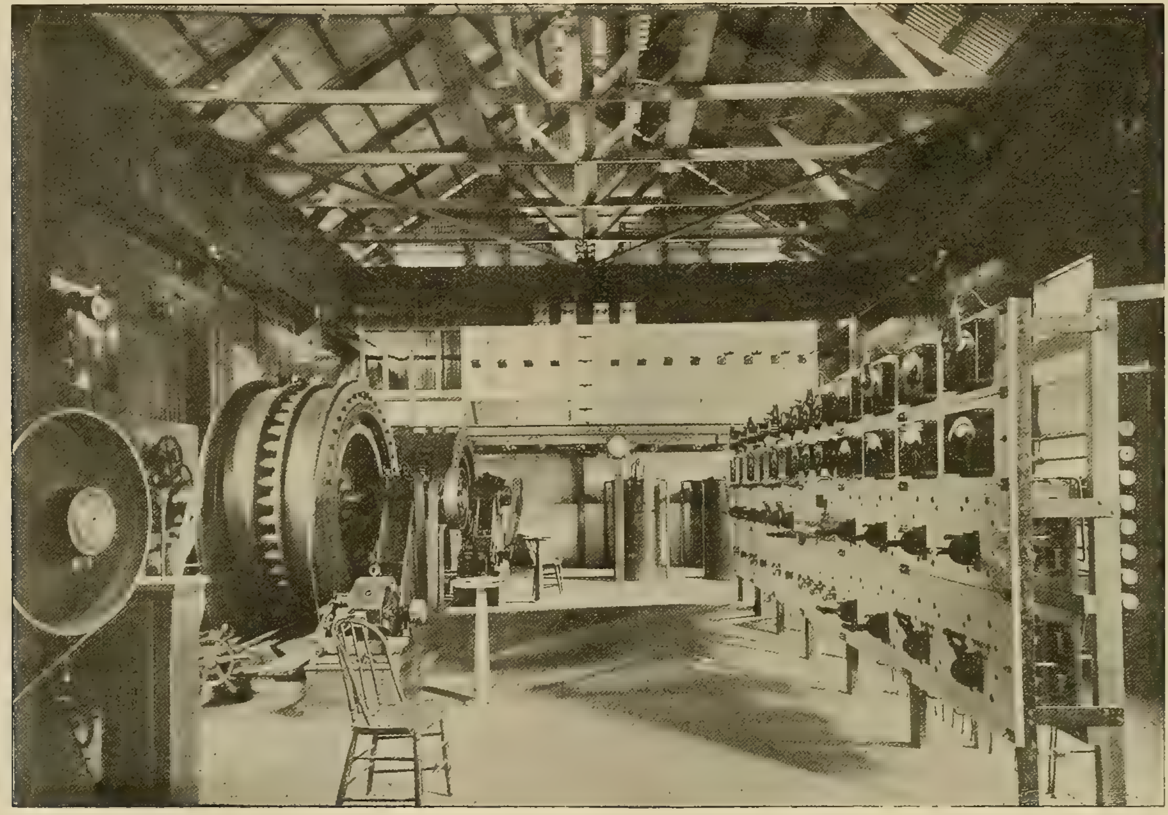
The method of crossing Dry Creek forms an interesting feature of the line construction. When "Dry" Creek, is a poser, for it always carries more water than many so-called rivers of California and in winter it oft-times becomes a raging torrent, unmindful alike to the welfare of bridges or of those who tempt fate at its fords. The bridge illustrated on page 146 is built on three massive concrete piers which will successfully withstand any flood, and it is to the lower side of the center one of these piers that a 50-foot pole is securely bolted and strapped by ½x5 inch band irons so that should the bridge be washed away the pole will stands as long as the pier does.

It was the good fortune of the writer to be at the power house during the first rain storm that occurred after the plant had been placed in operation. The weather had been threatening for a day or two and the rain which all felt would come sooner or later, was awaited with no little interest by those connected with the plant. Its advent was marked by a violent windstorm shortly before one o'clock one morning, and so hard did it blow that the inmates of the cottage were awakened by the shaking of the house and the spiteful beating of the sheet rain against the windows. It was a genuine mountain rainstorm of keen severity, but through it all the lights burned in perfect steadiness and the line circuits were as devoid of interest, electrically speaking, as a barbed wire fence. The test was a severe one and it demonstrated that transmission at 16,700 volts over a line supported on glass insulators and porcelain base iron pins, is not susceptible to interfereance by any natural manifestation of wind or water "short of typhoons and tidal waves," as one of the power house attaches put it.

The experience thus far has been that the line is without distinctive phenomena and so far as the practical operation is concerned, it is identical with any 10,000-volt line. It gives no brush discharge at points, such as from the ends of tie wires, it is silent and, in brief, the one who expects to find an outward evidence of the high potential carried will be disappointed in his search for it.

At the Power House.

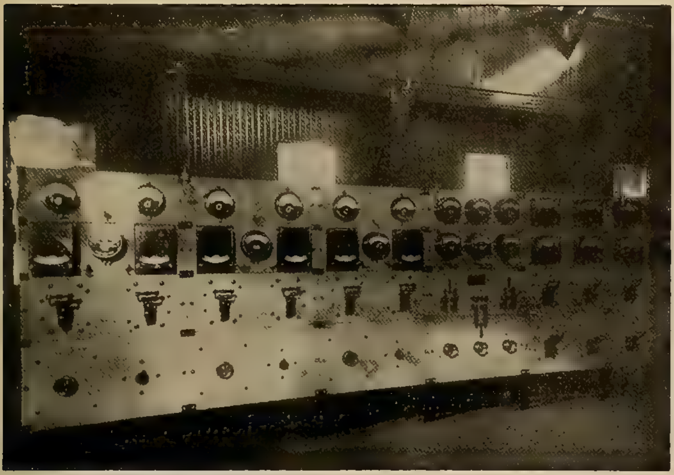
A seemingly interminably succession of road gates beset the traveler along the last portions of the road to the Yuba power house and, in affording barriers in plenty to restrain the roaming proclivities of stock, they prove equally efficacious in impressing upon the young man of the city, who jumps out and opens them, some features of country existence that he might not have observed otherwise. As the monotony of gate-openings is becoming about intolerable, without fore warning one finds himself almost within the grounds about the generating station, when a two minute drive down a hill, a rumble over a short bridge spanning the stream which comes down the ravine from the spillway in the main ditch half a mile above, and one is at the power house. It is a plain unpretentious structure of corrugated iron measuring fifty by thirty feet and finished within in tongued, grooved and beaded pine, oiled and varnished. The first impression of the station, and one which further investigation confirms, is that it is possessed of remarkable compactness, with careful regard to attain perfect ease of manipulation and control.



Interior of the Generating Station.

As one enters the station, three 360 kw. Stanley inductor type generators occupy the side of the station at the left, and their respective exciters, each belt driven from its generator shaft, stand in front of the generators. Next to the side wall are three water wheel governors of the relay type, while direct connected to each of the generators through a flexible coupling of four raw-hide links, is the shaft which, after passing through the concrete side wall of the building, carries a 700 hp. Pelton wheel. The hydraulic guage shows a running pressure of 127 lbs. per square inch, and belted from each generator shaft is a tachometer. Along the right hand side of the center of the station for seventeen and one-half feet extends the main switchboard in six panels of blue Vermont marble, placed well out from the side of the building. It is a very handsome board and contains several novel features that will be discussed presently. Across the rear end of the station at a height of eight feet above the main floor is a gallery on which is placed the high tension switchboard. It is separated five feet from the rear wall of the building and contains twelve Martin high tension switches which, as will be shown, form one of the most interesting features of the plant. On the main floor under the right hand half of the gallery are six, 125-kw. Stanley transformers, which take the generator potential of 2400-volts and deliver it to line at 16,700 volts through the Martin high tension switches. Overhead are the banks of Stanley lightning arresters with choke coils, and in a corner where its chains will be incapable of doing harm, is a ten ton travelling crane. A telephone booth and the usual station accoutrements together with an all-pervading cleanliness, completes the pen picture of the Yuba Power plant.

The site of the power house is about 700 feet above the sea level and is closed in on three sides by mountains, the side to the West being open, affords a charming view down Dry Creek Canyon, past mountain, hill and lowland, on for a background, to the great serrated Marysville Buttes, way out in the Sacramento valley nearly forty miles distant. Just below the power house where the vegetation of ages has enriched the soil and where the creek keeps the ground well irrigated, is the vegetable garden, above which are terraced lawns in which beds of flowers are now being laid. These reach to and around the cottage, a well built nine room house, hard finished, containing all modern conveniences and the veranda of which commands to best advantage the superb view just referred to. The mountains confining the power house location are great rolling hills with sides so steep that in places one is apt, if he missteps, to slide on the slippery grass for a rod or so before recovering his footing. The pipe line, main and spillway canals, tail race and cottage are on the northerly hillside; the ravine comes down from the East, while the road winds in through the oak trees on the hill toward the South. It is a walk of about half a mile along the tail race canal around the point of the mountain to the canyon where the inverted siphon is carried over Dry Creek. This forms the scene presented as the initial illustration of this article.


THE MAIN SWITCHBOARD.

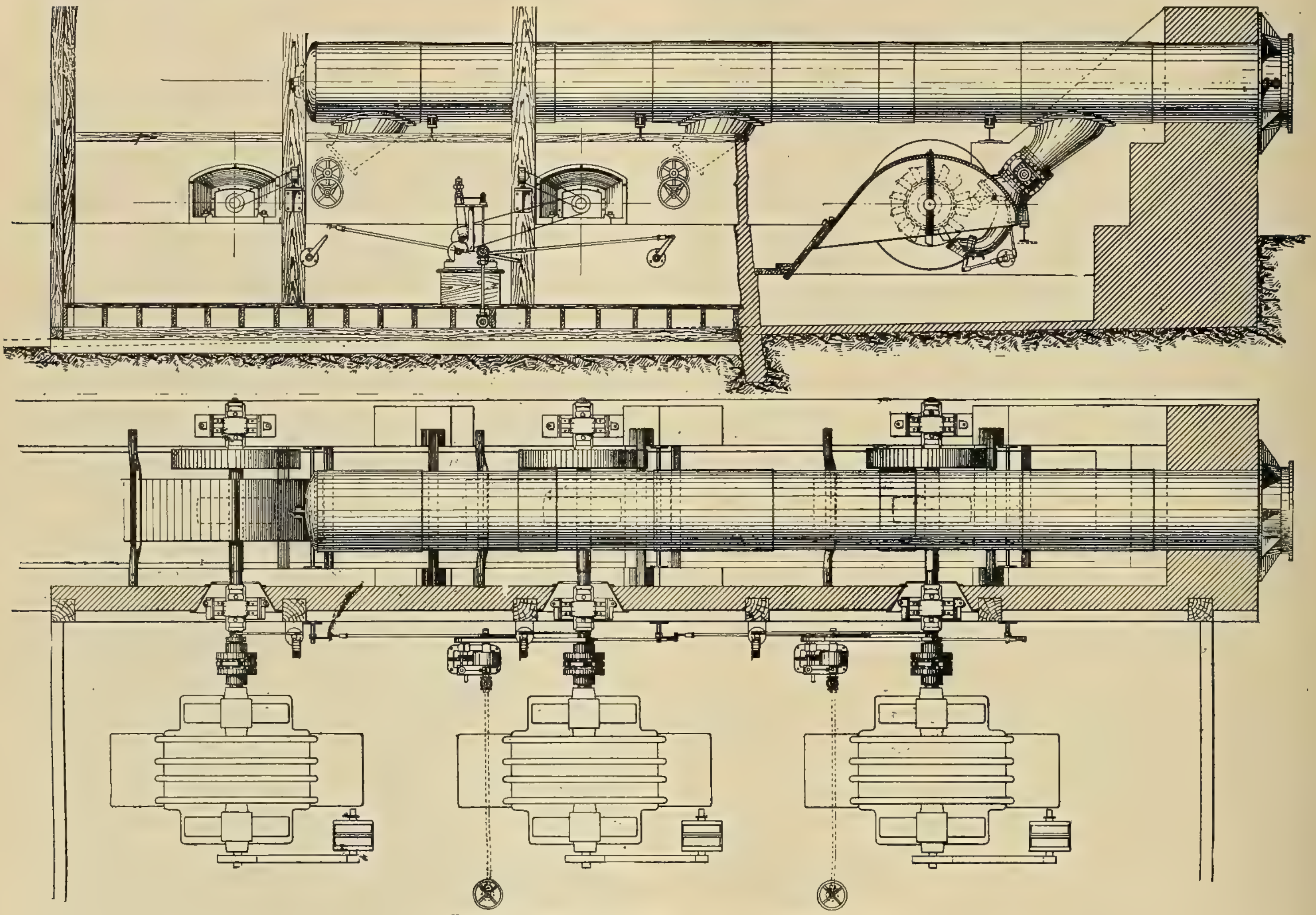
THE ELECTRICAL EQUIPMENT.

The general scheme of arrangement of the hydraulic equipment is shown on the accompanying detailed plan, from which it is seen that each of the 360 kw. generators is direct driven by a two nozzle Pelton water wheel, the generator exciters being driven by belting from the generator shafts. The general arrangement of the interior of the power house has however, been described in the preceding paragraph. "The S. K. C." inductor type generators of the Stanley Electric Manufacturing Company, are by far too well and favorably known to require detailed description, hence it suffices to state that the generators installed in the Yuba Power plant are of the standard form of Stanley inductor machines, operating at 400 revolutions per minute, delivering 360 kw. of energy in two-phase form at a periodicity of 8,000 alternations per minute, at a potential of 1200 or 2400 volts as desired. The generators in question, are coupled up for 2400-volt delivery, and the regulator head cuts in or opposes armature windings so as to give an increase or decrease of the electromotive-force of either phase amounting to ten per cent in ten steps of 1 per cent each. In order to minimize the sometimes pernicious effects resulting from the self-inductive discharge of field windings when operated at 110 volts or higher potentials, the Stanley Electric Manufacturing Company excites the fields at the comparatively low electromotive-force of between 50 and 60 volts. Four pole exciters of the Eddy type and having a capacity of 5 kw. each, at 1350 revolutions per minute, are used, and each exciter is of suffiient capacity for the excitation of any two generators.

PIPE LINE AND RECEIVER.

Beginning the enumeration at the left, the first three panels of the main switchboard are for the three generatars rspectively; the fourth panel is the exciter panel, while the fifth and sixth panels are for the control of the step-up transformers. Each of these panels has a width of 36 inches, and each consists of four sections. In the generator panels, the upper section carries, in addition to a 52-volt pilot lamp, two, circular type, 100-ampere, dead beat ammeters; these are a new form of hot wire ammeter just brought out by the Stanley company and are remarkably dead beat as well as accurate. The second section of each generator panel carries a Weston direct current ammeter, having a range from 0 to 50 amperes for the field circuit; two, 100-volt incandescent lamps, with key sockets for synchronizing purposes with the other generators, and two static voltmeters having a range of from 1400 to 3200 volts, one being used for each phase. These static voltmeters, which were recently brought out by the Stanley company, and are of a new type as well, are placed directly across the generator terminals. The third section of the panel carries two double pole, double throw switches of the standard Stanley enclosed break type, illustrated herewith, and so arranged as to throw the phases on to either of two sets of bus-bars of four wires each, which run along the back of the entire length of the switchboard. The switch to the left, controls the leading phase and that to the right controls the lagging phase. The illustration of the switchboard shows all switches to be in the upward position, hence both phases of the three generators are thrown in parallel on the upper set of four bus-bars. The fourth and bottom section carries the field rheostat at the left and a double-pole field switch at the right.

The exciter panel presents no deviations from the regular form. The three vertical rows of instruments and appliances ae for the three exciters respectively. The upper section of the panel carries three 0- to 100-ampere Weston ammeters; the second section carries three 0 to 75-volt Weston volt meters, immediately below each of which is a 52-volt pilot lamp. The third section carries three 150-ampere, double-pole knife switches for throwing the exciters in or out of circuit with a single common exciter bus-bar; while the fourth section carries the three handles for the three field rheostats. Contrary to a common practice, no incandescent service is rendered from the exciters, the output of which is used for excitation purposes alone.

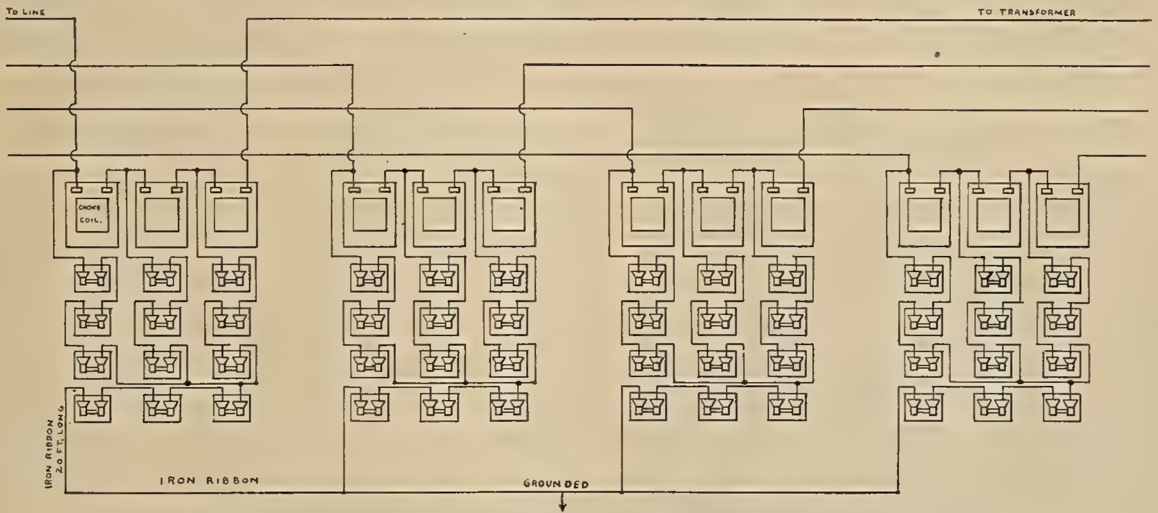

DETAILED PLAN OF HYDRAULIC EQUIPMENT.

The remaining two panels of the switchboard are for the handling and control of the primaries of the step-up transformers exclusively, each panel controlling two of the 125 kw. raising transformers. The upper two sections of the two panels carry eight alternating current ammeters, each having a capacity from 0 to 75 amperes, and the lower two sections of the two panels carry eight Stanley double-pole, double-throw switches of the type described. Each of these switches controls the primary of a single transformer, enabling it to be cut in on either the upper or lower set of bus-bars as desired. As but six transformers are installed, one set of switches and ammeters is not in use at present.

The synchronizing connections are shown in the diagram given and synchronism is indicated by the lamp being out. The process of synchronizing consists of bringing the generator up to normal speed and voltage. When the synchronizing lamp indicates synchronism the generator switch is closed, thus connecting the generators in multiple. After the generators are connected to the same set of bus bars, the individual volmeters no longer indicate the voltage on each generator, but the resultant voltage delivered to the bus bars. In order to determine the proper excitation to prevent an exchange of armature current, the ammeters in the exciting current circuit of each machine is used and the exciting current adjusted in accordance with the load carried.

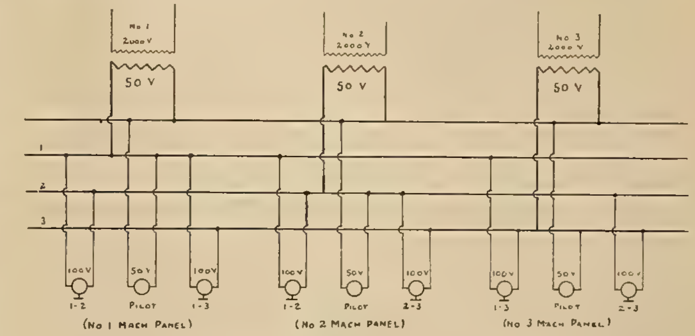
The lighting arresters are of the new type recently brought out by the Stanley Electric Manufacturing Company, and are arranged as shown in the diagram. Three choke coils are placed in series with each wire of the circuit. These choke coils offer impedance to the high periodicity current of the lightning discharge and at the same time add no self-induction to the line.

The connections from line to arresters is No. 6 copper wire but the ground connection from each bank of arresters consists of iron ribbon of about twenty feet in length. This arrangement was selected on account of the greater conductivity of iron ribbon for static charges and at the same time introducing a certain amount or resistance between the two wires of a circuit in case of a short circuit resulting from a discharge from both wires at the same time.



Connections of Stanley Lightning Arresters for 16,700 Volts.

All leads to and from generators and exciters as well as to the step-up transformers are carried in ducts beneath the floor. The switch board is as stated, of blue Vermont marble supported on angle iron frames, and carrying in the rear a wooden skeleton on which are run the two sets of bus-bars, the synchronizing wires and the generator and transformer leads. The front side of the switchboard contains no live high tension circuits, and the board itself is a very handsome one. The practice of placing a direct current ammeter on each generator panel for the purpose of giving a direct reading of the field amperage is an innovation in Stanley plants on the Pacific Coast, while the presence of the new and exceedingly valuable types of Stanley dead beat ammeters and static voltmeters, is a further novelty.

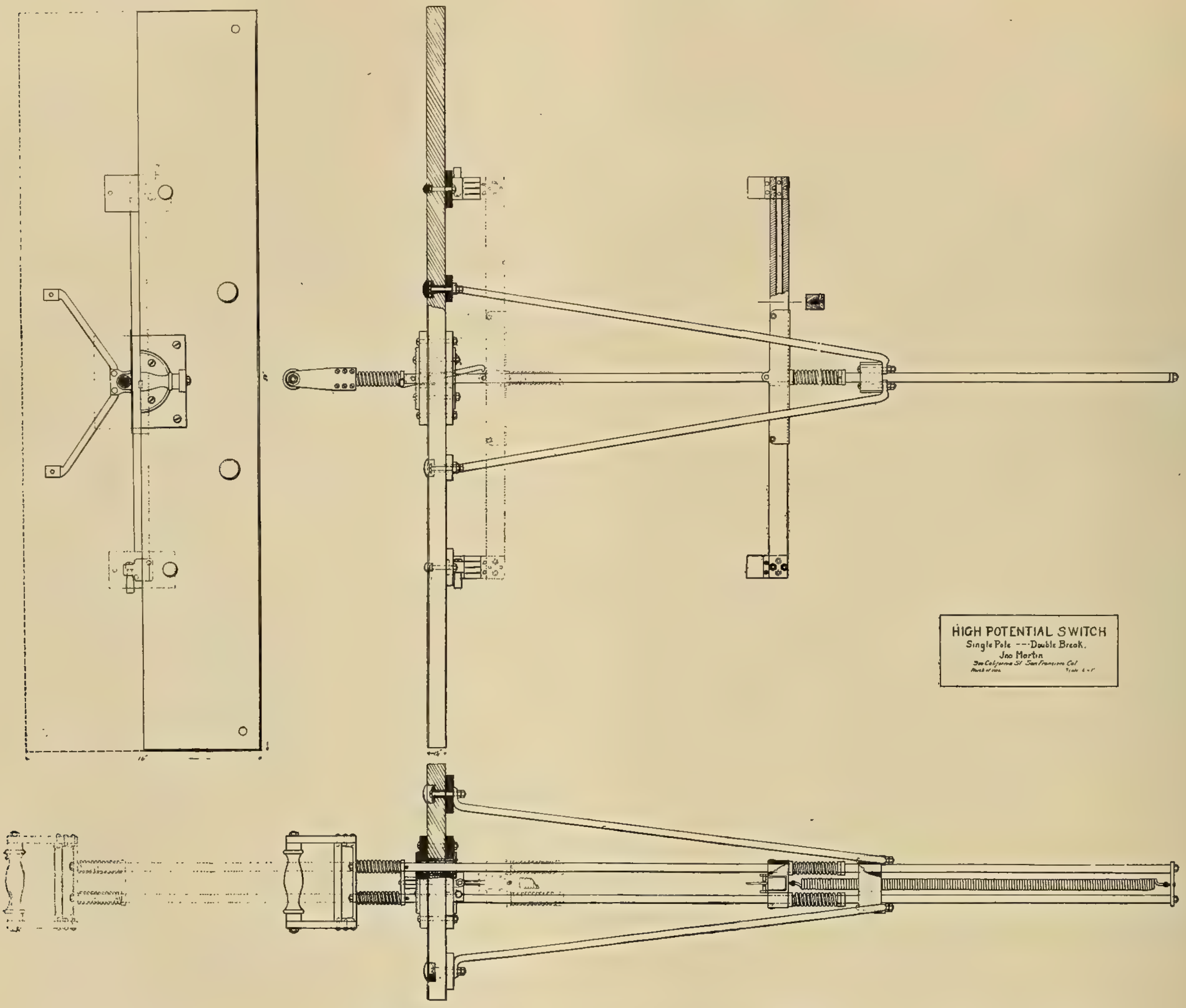


The Synchronizing Circuits

The six, 125 kw. step-up transformers, which take the generator potential of 2400 volts and transform it to 16,700 volts for transmission purposes, are of the static type, and are incased in boiler iron jackets, having a height of 72 inhes and diameter of 32 inches. The transformer core consists of L-stampings with broken joints which are placed around one side of each of the elliptical coils that extend along the length of the transformer. These two coils each contain both primary and secondary windings and are placed back to back, hence there is but a single core which extends axially in the transformer case. The case is filled with a high grade insulating oil and is water cooled by means of a worm of one-inch galvanized iron pipe closely coiled and placed next to the case and through which a small stream of water constantly flows.

The secondary leads of the transformers extend directly up to the rear of the high tension switchboard on the gallery immediately above. The feature of this switchboard is, of course, the high tension quick break switch, full details of which are presented in the accompanying outline drawing. It is a single pole quick action switch, making two breaks of 18-inches each, hence has a 36-

inch break. All portions of the switch on the front of the board are grounded, which eliminates danger from shock. Referring to the drawing below, it will be seen that the switch handle manipulates two parallel rods carrying the movable arm that gives the double break. To increase its rigidity, these parallel rods are supported at a distance of 22 inches by angle braces attached to the back of the switchboard, and the act of drawing the switch handle forward closes the circuit by the natural means of pulling the blades of the switch into the clips attached to the back of the board. It is, of course, simplicity itself to close a high tension switch, but the trouble which occurs from the use of such appliances always develops at the instant of opening the circuit. To obviate the difficulties, the Martin high potential switch accomplishes an exceedingly long break—as long as may be desired—in an exceedingly short interval of time. The behavior of this switch in breaking a 30,000-volt circuit is fully described in another article appearing in this issue.

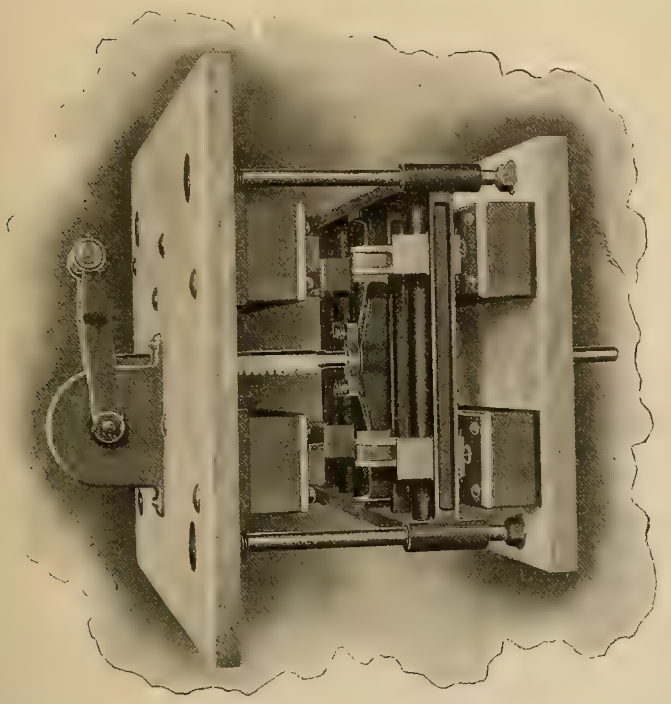


DETAILS OF THE MARTIN HIGH TENSION SWITCH.

Reverting again to the outline drawing, and in particular to the dotted portion of the larger cut, it will be seen that the act of closing the switch by drawing it forward has engaged a projection on the switch bar with a trigger which holds the switch bar rigidly in place until the handle has been pushed forward its full length, when the trigger releases the catch and the switch bar is instantly drawn back by the tension of the long spring which was distended during the act of pushing the switch forward. The shock given by the receding switch bar is so thoroughly taken up by spring and rubber bumpers shown on the two parallel rods, that it is practically imperceptible. The stroke of the handle is 20 inches, and the switch extends a distance of 38 inches out from the back of the switchboard; but the space occupied is of no objetion, where the high tension switches are erected on special galleries, as they certainly should be in every instance.

Going Over the Water System.

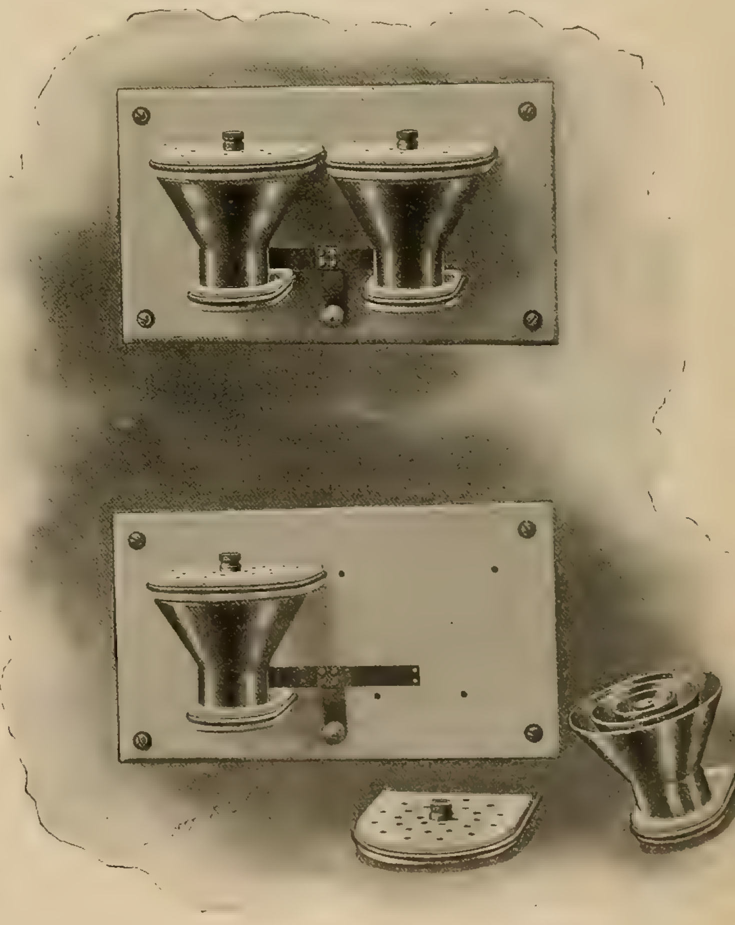
To examine the water supply of the Yuba Power Company will consume about two days, when the investigator will have gone over only the most interesting features of it and, in going to the head waters, one does not ride those twenty-eight odd miles from the power house up to Dobbin's Ranch without having developed substantial evidences of having been doing something. Among these evidences, the imperative mandates of a ravenous appetite are paramount. We hastened to pledge ourselves to "live in peace forever" by washing in the tin basin and wiping on the roller towel that, in company with a wooden sink, adorn the front entrance of Dobbin's Hotel and, the semi-ablutions over, mine host Merriman, who rightly named, laughs uproarously at every remark, however staid,—is given no opportunity to make second announcement that supper is ready. We were very hungry for we had undergone, or rather overgone, momentous expeiences along tedious roads where the conveyance throws you up in the air, drops you, then meets you half way in abrupt unceremony; we had, in pharaphased electrical parlance, been over a long distance, high joltage line and, once seated at the table, we quickly encompassed every feature presented in the interesting "transmission" then under consideration.



A STANLEY DOUBLE POLE DOUBLE THROW SWITCH.

Dobbin's Ranch is but a very little place well up amid the pines of Yuba County and one would soon forget it, with its handful of houses, its rural sleepy ways, and its frogs' chorus at eventide, were it not that, in sitting around the stove in the country store that bears the Dickensonian name of "Slingsby & Gettens" you meet and listen to the experiences of Daniel Gettens, whose marvellous memory, ready wit and relation of stirring experiences of the days of '49, hold you in bonds of deepest interest until long after the time when one should have retired in prepration for the early start on the morrow. Nevertheless, we were up betimes and away shortly after day break on the five mile drive to the little saw mill at the top of the mountain over the river canyon, the nearest point that the wagon road approaches to the upper end of the flume.

Speaking personally, I can not say that any particular pleasure was experienced in going down the trail from the saw mill to the flume. The trail literally stood on end, and it was said that its length was a mile,—in my estimation it was very much of a mile indeed. I do not walk for a living, as the guide for that trip has done for years, and it had been my fortune the afternoon before to go with him from the power house to photograph the flume over Indian Creek. I understood it was to be a five mile walk to Indian Creek and I struck out in his footsteps with agility. Mountaineers walk up hill and down dale with the measured, incessant, unrelenting tread of a perpetual metronome. They never stop, they never tire, nor lose their breath, nor get a-thirst, nor take "spells" nor look at landscapes however enchanting. Their sole ambition is to push the world behind them with their feet until the desired spot on the earth has been at last brought to them. My guide was of this ilk. We went up and over and down six big mountains in his merciless metronomic way before we reached Indian Creek, where I hustled around and took the photographs

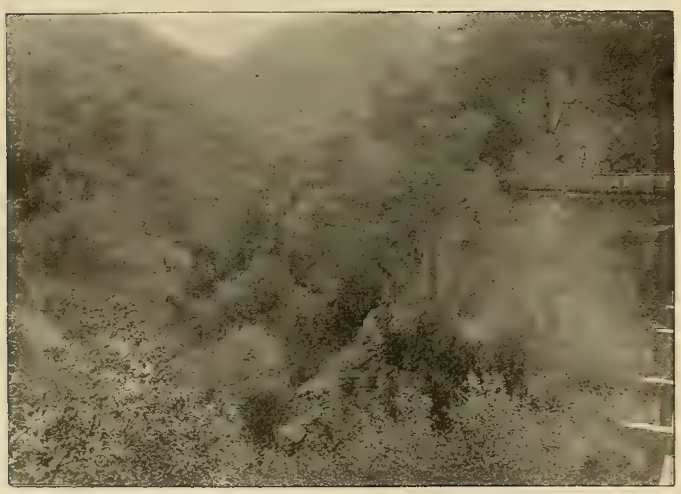


THE STANLEY LIGHTNING ARRESTER.

while he sat on the flume,—except during the moment of picture taking. Then we started back at once on the same gait, but not until after I had held him long enough to remark that we had gone a long way, it seemed to me, for one half of a five mile walk. "Five miles each way," quoth he, speeding onward. But as we neared the power house, my aching, quaking knees gave out and, in coming down from the head of the pipe line, I was glad the slope was steep enough so that I could ape "Kelly" of vernacular fame, and "slide". On reaching the power house in a state verging on collapse, explanations followed and I found that the five miles was an "air line" distance and that, soft of muscle as I was, I had walked in mechanical precision almost twenty miles that afternoon over trails so rough and steep as to beggar description.

THE DAM AND HEADWORKS.

And so, with aches which large and oft-repeated applications of pain killer had allayed not, my stiffened joints quaked in descending the trail from the saw mill to the flume and I contemplated the prospective absence of an ambulance at the end of the day's trip ten miles away, (so my guide said) with feelings akin to despair. The alpenstock did little good in the descent; I clung desperately to the chapparal and young maple as I tried to lower myself down easily, and finally had about concluded to accept the guide's advice to "grease the ways and slide" again, when we reached the flume, hidden amid the trees and brush. Then was experienced, although with some misgivings as to the outcome, the dubious satisfaction of the knowledge that most of the rest of the walk would be on a level flume which, thank Heaven, would bear some semblance to the sidewalks of a civilized community.



NEAR THE CONFLUENCE OF THE NORTH AND MIDDLE YUBA RIVERS.

The lumber with which the flume was built was cut by the little saw mill at the head of the trail, whence it was carried down the mountain in a wooden chute, the trip being covered in considerably less than a minute. It is one and a half miles from this point up the flume to the dam, with an equal distance over trails in reaching and leaving the flume, and as the flume is seven miles in length, it requires ten miles of walking to go over it. Here a characteristic of nearly all flumes leaves an indelible memory on the mind of the one who visits these mountain fastnesses only once in a while. The boards constituting the foot walks on the upper portion of the Yuba flume are new, wide, and very firm, but the further down one goes the narrower they become until eighteen inch boards drop to a width of twelve inches, then to ten inches and down on to eight, six, and even five inches, until one is constrained to believe that if the flume were say fifteen miles in length, the foot boards along its lower end would be but bed-slats, or maybe like whalebones, or even necessitating, perchance, that to go over the flume one should be possessed of the equilibristic qualifications of a tight rope walker.

A MILE BELOW THE DAM.

The principal features of the flume are well brought out in the accompanying half tone engravings. Its upper portion before the North Fork of the Yuba joins the Middle Fork, is especially interesting because of the precipitous canyon sides, the graceful windings of the flume and the wealth of foliage. After leaving the confluence of the two streams the elevation of the flume above the muddy waters of the Yuba gets constantly higher until an elevation of 800 feet is attained, but nevertheless, the route along the mountain side under the blazing sun grows uninteresting, monotonous and wearisome as the lower end is approached, and when at last the flume tender's cabin, marking the terminus is reached, the unprofessional walker finds himself thoroughly hot, fagged, and quite unprepared for the hard, exasperating climb that confronts him up an almost perpendicular trail over half a mile in length. This done, the conveyance is found awaiting at the top of the mountain, while with it has come thoughtful Dan Gettings with restoratives that cheer, and the trip over the Yuba flume, like the adventurous tenderfoot's physical endurance, is practically at an end.

THE FLUME CROSSING INDIAN CREEK.

The Water System.

The water supply of the Yuba Power Company owes its development to the Wright irrigation law under which the Brown's Valley irrigation district was organized some ten years ago. This irrigation district, which covers an area of about 33,000 acres, was bonded for $140,000 in all, and this amount was expended in the development of the water system, that is now the leased property of the Yuba Power Company for a term of fifty years.

Water for the system is taken from the North Fork of the Yuba river at a point in Yuba county about four miles above its confluence with the Middle Fork of the Yuba river. The minimum flow of the North Yuba river, as the North Fork is called, at the point of diversion, is never less than 16,000 miners inches, all of which is located and controlled by the Yuba Power Company, not only by right of the lease mentioned, but also by right of absolute ownership of over 2000 acres of land upon which the dam, flume, power house and sub-station are erected. Inasmuch as the maximum amount of water required for the operation of the present installation for electric transmission purposes, is about 2300 inches, it is evident that there is no ground for apprehension that the water supply may prove inadequate to satisfy all demands. Moreover, should the demand for power by any chance exceed that which is available under the head at which the present plant is operated, the power house could be moved to a point further up in the mountains, and toward the lower end of the flume where a head of over 800 feet, instead of 300 feet as at present, is available. In this instance water for irrigation purposes would be carried on down the ditch in quantities about equal to its present capacity, while the remaining 12,000 or 14,000 miners inches would be available for power purposes at the high head given.

A substantial crib dam, 30 feet in height and having a width of about 150 feet, is thrown across the narrow gorge of the North Fork at the point indicated and as appears, in the illustration on page 154.

At times the river becomes torrential, but any danger of the washing away of the flume intake is averted through the particularly advantageous location of two great rocks between which the diversion of water to the flume is made. There is practically but one flume in the system and this is the main flume which extends a distance of not quite eight miles down the side of the canyon from the dam as appears in the accompanying engravings. For a distance of five miles from the diversion the flume has a width of five feet and is three in depth, but when the construction of the flume had progressed thus far, the plan originally adopted by the irrigation district was changed by reducing the width of the flume to four feet, the depth remaining as before but with increased grade so as to give equal carrying capacity. The ditch proper is 23 miles long, is 5 feet wide on the bottom, nine feet wide on top and is 2½ feet deep. Its fall is 9.6 feet per mile.

AFTER CLEARING OUT THE OLD DITCH.

Prior to the lease by the Yuba Power Company, the entire system had been permitted to run down, but during the past winter the ditch has been deepened, straightened, and freed from rocks and slides, while the main flume has been so repaired that it is now in the very best of condition. In fact during the recent trip of the writer over it, the flume was found to be the tightest of any yet seen in California power transmission plants. Several short and comparatively unimportant flumes are placed in crossing ravines along the line of the ditch, and the most important of these is that at Indian Creek illustrated on page 155. The Indian Creek flume is built on an arc, which gives it the appearance of sagging so noticeable in the illustration.

The especial value of the Brown's Valley irrigation system for power purposes rests in a 300-foot "drop" or fall which occurs in the ditch at the point where the power house is located. The original plan of the system and as operated for a number of years, consisted in the carrying of the ditch along the side of the mountain forming a southerly border of the precipitous canyon, through which the waters of Dry Creek flow. The elevation at which the ditch appears on the side of the side of the mountain is too great to be available for the canals on the lower land beyond the opposite side of the canyon. The upper ditch, therefore, formerly emptied into a natural ravine along which it flowed for probably half a mile when it was picked up by a lower ditch and conyeved to the side of the canyon across which it was carried by the "inverted siphon", as the pipe line over Dry Creek is called. The "siphon" is such only in name for it is merely a pipe line supported by a suspension bridge and on the sides ofthe canyon to the ditch on the opposite side which is at a slightly lower elevation.

It is this drop of approximately 300 feet that was available for power purposes and which, considering the favorable market that was near by, led to the organization of the Yuba Power Company. The power house is located at the foot of the ravine referred to and the changes effected in the original system consist, first, in extending the old ditch along the mountain side past the ravine to a point where the use of a shorter pipe line for water wheels was made available, and, second, the building of a new ditch to take the water of the tail race to the inverted siphon at a point some 70 feet below the one to which water was delivered to the pipe under the original system,—the reason for this being that the head at which water was formerly delivered to the inverted siphon was greater than necessary, and the saving of which head increased by that much the working head of the water applied to the wheel. Both the ravine and the old lower ditch (which has been superseded by the new tail race) are now used as spillways, and all the water spilled from the main, or upper canal, together with that from the tail race, is delivered to the different portions of irrigation system below.

DIGGING THE DITCH EXTENSION.

At first glance it appears that the weak point about the water system rests in the absence of a storage reservoir at or near the head of the pipe line. This weakeness however, is apparent rather than real, for the reason that the storage capacity of the 23 miles of ditch is such that by closing the intake, there can still be delivered to the wheels 2361 miners inches of water for a period of 10 hours. In addition to this, by damming the ditch in various places, some forty in number where spillways are located, an additional storage capacity of 1000 miners inches for six hours in obtained. Moreover, it is not possible for any break to occur that can not be repaired within six hours, hence the liability of interruption of water supply is neglible.

DRY CREEK CANYON AT THE INVERTED SIPHON.

A further feature affording additional safeguards to the water supply is found in the metallic telephone circuit extending along the ditch and flume. In this system the flume and ditch tenders plug in their portable telephone test sets where at work or while on patrol, means being provided on each alternate pole by use of spring jacks properly protected from the weather.

THE HYDRAULIC EQUIPMENT.

The main ditch terminates in a wooden penstock, measuring ten feet by ten feet by ten feet in depth, whence the pipe line continues in a straight line down the hill side, to the receiver, also in line with the pipe line. The receiver and pipe line have a diameter of 42 inches except in the upper four courses of the pipe line which taper out to a diameter of 54 inches at the point of entrance to the penstock. The pipe is built of steel varying in thickness from one-eighth of an inch to one-quarter of an inch and the pipe was hot riveted, when of numbers 7, 5 and 3 steel, and cold riveted on the remainder. The effective head is 292 feet, and the line which rests on top of the ground and is well anchored throughout

As stated elsewhere, three Pelton wheels are used each being connected by a flexible coupling to its respective generator. These wheels are 40 inches in diameter, and are each supplied with water from two, four inch nozzles. Each wheel had fourteen cast iron buckets, and on each wheel shaft outside the wrought iron housing is placed a 6,000 lb fly wheel. Self oiling and self aligning bearings are used throughout and the wheels are driven at a speed of 400 revolutions per minute. Regulation is effected by the use of deflecting hoods.

A peculiar feature of the hydraulic plant, is the fact that the capacity of each wheel under the head available, is 700 horse-power, while the generators have a rated capacity of but 480 horse-power. The reason for this is a logical one; the generators have an aggregate rated capacity of 1440 horse-power, which marks the normal capacity of the plant; under ordinary conditions however, it is not advisable to load a plant to the full capacity of its generating units without a reserve in the plant for emergencies, but in the Yuba plant it is perfectly safe to load the three generating sets to their rated capacity as in event one set is disabled, the two sets remaining which can be overloaded 50 per cent will prove adequate to carry the load of three generators, because of the fact that the water wheels each have a capacity of 700 horse-power. The water must at all times be delivered from the upper ditch to the tail race in order to supply the irrigating system below, hence the saving of water is not a factor.

PERSONAL AND FINANCIAL.

The conception of the plan of the Yuba Power Company and the realization of the many advantages it possesses for an electric transmission plant that would from the outset prove remunerative and which would form the nucleus of the system that will, in the near future, supply electric service to many prosperous localities within a wide radius, was due conjointly to Messrs. R. R. Colgate and Jno. Martin who have from the outset been the leaders in the project, both in an active and financial sense. Mr. Colgate, in addition to important holdings in a number of electrical interests throughout the West, is manager of the Atlantic branch of the National Lead Company, New York, and Mr. Martin is so well and favorably known as the Pacific Coast Agent for the Stanley Electric Manufacturing Company that he requires no introduction to electricians. These gentlemen together took up the entire bond issue of the Yuba Power Com-

PENSTOCK OF THE INVERTED SIPHON.

Company, amounting to $230,000, beyond which there is no outstanding indebtedness.

The Yuba Power Company is capitalized at $300,000, of which all is subscribed by Messrs. R. R. Colgate, W. Frank Pierce, W. M. Pierson, E. J. de Sabla Jr., and Jno. Martin, who constitute the Board of Directors. The officers of the Company are: Jno. Martin, president and general manager; E. J. de Sabla, Jr., vice president; and John Williams, secretary.

The power house, pipe line and pole line were located and surveyed by Mr. Jason R. Meek, C. E., county surveyor of Yuba County. The general arrangement and execution of engineering design of the power house, pole line and sub station was under the direction of Mr. Theo. E. Theberath, chief electrician for Jno. Martin, and who was ably assisted by Mr. F. V. T. Lee, Mr. Martin's assistant electrician, and Mr. Frank Vannata, chief electrician of the Yuba Power Company. The commercial features of the system are handled by Captain J. F. Luttrell, local manager for the Company at Marysville, and the clerical department is in the hands of Mr. H. S. Battle. The sub-station and distribution is being operated under the direction of Mr. George W. Dietz, who executed the contract for the building of the pole line. The flume and ditch is patrolled by six men under the superintendency of Mr. Charles L. Armstrong, who is one of the most capable men in this capacity to be found in California.

There are but few electric transmission plants that have been able to start in operation with a contracted load amounting to over sixty-eight per cent. of the capacity of the generating plant, as is the record of the Yuba Power Company, and this load consists of 300 horse power for the Pennsylvania and Webb mines, in Brown's Valley; 225 h. p. in the Buckeye Flour Mill of the Sperry Flour Company at Marysville, besides numerous other small power installations. The Company has also secured the municipal contract for the arc lighting of Marysville during the next fiscal year, for which service an induction motor and arc dynamo set, probably direct connected, is soon to be installed in the sub-station. Its capacity will be about 60 2,000 c. p. lamps, or say, 50 h. p. Moreover, the Company is now operating about 3,000 16 c. p. incandescent lamps and has approximately 2,000 lamps more under contract which it is installing as rapidly as possible.

Distribution is effected through two sub-stations as intimated heretofore, the principal one being the Marysville sub-station, which is an exact counterpart of the power house as to material and type of construction, finish, and size. It is located on the East side of the city near the levee and contains four step-down transformers, each having a capacity of 125 kilowatts and being practical counterparts of the transformers at the power house. They deliver nominally 2,000 volts to the local distribution, which is further reduced to 110 volts for incandescent lighting purposes by means of Stanley type "G" transformers on the two-phase system. The distinctive feature of these sub-station transformers is the fact that they are each provided with a regulator head by means of which the secondary voltage may be raised or lowered as desired by ten per cent., in ten steps of one per cent each. They are water cooled, the water for which is obtained in the Marysville sub-station, from an artesian well by an electrically driven pump. At present there is no regular attendant at the Marysville sub-station, nor will there be necessity for one until the motor-generator arc lighting set is installed for fulfilling the street lighting contract with the city. All arc lighting now operated by the Yuba Power Company is of the constant potential alternating current type.

The substation at Brown's Valley is located at the Webb Mine, in a portion of the engine room, but inasmuch as the mine is soon to be driven by electricity, the steam plant will be abandoned and the equipment will be an all-electric one. This sub-station contains two step-down transformers, similar in every way to those at Marysville, and, like the latter sub-station has a full equipment of switchboard and lightning arrester apparatus.

Among the principal contractors for the installation were Messrs. Schaw, Ingram and Batcher, of Sacramento, who built the pipe line; the Union Lumber Company, which furnished the poles; Mr. Jno. Martin, agent for the Stanley Electric Manufacturing Company and of Fred M. Locke's insulators and line materials; the California Electrical Works, which built the high tension switches under the specifications of Jno. Martin; and the Pelton Water Wheel Company, which installed the water wheels and hydraulic equipment at the power house.

ENGINEERING DATA OF THE YUBA POWER COMPANY'S PLANT.

WATER SYSTEM.

Length of Flume: 7⅞ miles.
Dimensions of Flume: First five miles, width 5-ft., depth 3-ft; remainder, width 4-ft., depth 3-ft., at increased gradient.
Gradient: Average fall of 14-ft. to the mile.
Lumber used: 1,250,000-ft.
Length of Canal: 23 miles.
Dimensions of Canal: Width at bottom, 5-ft; width at top, 9-ft; depth, 2½-ft.
Gradient: Fall of 9.6-ft. to the mile.

PIPE LINE.

Length: 850-ft.
Diameter. 42-in., except upper four courses which taper out to 54-in.
Material: Steel, varying in thickness from ⅛-in., to ¼-in.
Rivited: Hot on Nos. 7, 5 and 3 steel; cold on No. 10.
Receiver: Diameter, 42-in.; lengtht, 50-ft; Material, ¼-in. steel.
Head: 292-ft., effective.

HYDRAULIC EQUIPMENT.

Kind of Water Wheels: Pelton, tangential.
Number of Pelton Wheels: 3.
Diameter of Wheels: 40-in.
Number of Nozzles per Wheel: 2.
Diameter of Nozzles: 4-in.

Number of Buckets per wheel: 14.
Weight of Fly Wheels: 6,000-lbs. each.
Regulation: Relay governors controlling deflecting hoods.
Connections: Direct to generator units through flexible couplings.
Wheels housings: Wrought iron.
Speed: 400 r. p. m.
Capacity: 700-h. p. per wheel.

ELECTRICAL EQUIPMENT.

Type of Generators: Stanley two-phase inductors.
No. of Generators: 3.
Capacity: 360-kw. each.
Generator potential: 2400 volts.
Periodicity: 8,000 p. p. s.
Type of Exciters: Eddy, 4-brush, multipolar.
No. of Exciters: 3.
Capacity of Exciters: 5-kw. each, at 1350 r. p. m., and 60 volts.
Type of Transformers: Stanley static, oil insulated, water cooled.
No. of Transformers: 12, of which 6 are used as raising transformers in Generating Station, 4 as lowering transformers in Marysville sub-station, and 2 as lowering transformers in Brown's Valley sub-station.
Transformer potentials primaries, 2400 volts; secondaries, 16,700 volts.
Transformer regulation: Special regulator heads on step-down transformers for raising or lowering secondary voltage 10 per cent, in ten steps of 1 per cent, each independent of Generating station.
Capacity of transformers: 125-kw. each.

POPE LINE.

Length of Marysville line: 18¾-miles.
Length of Brown's Valley Line: 7¼-miles.
Length of Poles: 30, 35, and 40-ft., according to location.
Size of Poles: 12 in. to 20 in. at butt; 7 in. to 9 in. at top; round, 12-20 in. 7-9 in.
Material of Poles: Cedar and spruce in equal quantities.
Butts: Tarred, one-sixth of pole length in ground.
Distance between poles: 120-ft., 44 to the mile.
Right of way: 100-ft. wide, cleared.
Guys: Inverted "T" stubs at corners and angles.
Kind of Cross Arms: 4-pin, pine, iron braced and painted with P. & B.
Size of Cross Arms: 3-in. x 4-in. x 5-ft.
Distance between Cross Arm Centers: 18-in.
Distance between Pin Centers: 18-in.
Distance between Power Wires: 18-in.: phases on diagonals.
No. of Power Cross Arms: 2.
No. of Telephone Cross Arms: 1.
Ties: Western Union long tie.
Insulators: Locke, 5½-in., triple petticoat, annealed glass.
Pins: ½-in., steel, with Locke porcelain base.
Size of Power Lines: No. 6, B. & S., medium hard drawn copper.
Size of Telephone Lines: No. 12, B. & S., bi-metallic.
Telephone Line: 5-ft. below lower power line.
Capacity Marysville Line: 750-kw., ten per cent line loss.

Personal

Lieut. W. Stuart-Smith, U. S. N., has been called from the retired list to active service in the Navy and has reported for duty in the steam engineering department at Mare Island Navy Yard.

Mr. Leon W. Bly, late chief of the testing department of the Wagner Electric Manufacturing Company, but more recently of the engineering corps of the Telluride Power Transmission Company in the installation of the Provo-Mercur transmission, is in San Francisco and hopes to locate here.

Mr. James T. Stockdale has received a well deserved promotion from the position of assistant engineer of the San Francisco office of the General Electric Company, to the Power and Mining Department of the same company at the Schenectady Works. Mr. Stockdale's host of friends in California, in congratulating him on his advancement, will deeply regret his going away.

Miscellany

THE THIRD RAIL SYSTEM IN A SNOWSTORM.

The great snowstorm of January 31st last, which raged over New England, has proved that a railroad can be operated by the third rail electric system under the most adverse conditions. That portion of the New York, New Haven & Hartford Railroad, between New Britain and Hartford, operated by electricity, was kept open during the whole of that day and the trains were run with but few seconds delay in the schedule; while the steam trains on the main lines were held up and delayed for three or four hours.

A heavy snow storm had long been desired by the electrical engineers and railroad officials in order that as severe a test as possible might be applied to the third rail system. It has been a question whether, with the third rail practically surrounded by snow and moisture, the electricity would remain on the rail in sufficient quantity to furnish the necessary current to the motors on the cars. This question was settled by the snow storm. There was absolutely no leakage and once the heaviest part of the snowfall was removed by the snow plows, no interruption in the motor car service occurred.

ALASKA AS IT IS.

Although the public is about sated with Klondyke literature of the kind that appears in the daily press, it still is anxious to get reports that bear the imprint of genuineness and reliability,—something that savors neither of the "paddings" of the sensational press nor of the flaming verbosity of the writers in pay of transportation companies. A disinterested and reliable statement of fact is desired above all else, and when this fact is from the pen of a well known traveler and lecturer whose honesty of purpose is established, it is of treble value.

"Alaska, its waters, land and life," is a pamphlet that fills these requirements and throughout one is interested in the graphic descriptions of the truly wonderful region which is the Mecca of thousands of gold seekers. The author, Mr. John E. Bennett, takes the traveler from San Francisco through Juneau and past the glaciers clear on to Unga and Unalaska, then by the High Kotusks and the waters of the Lewis Yukon, as well as along the Dyea river, the Chilcoot Pass and Lakes Lindeman and Bennett and the White Horse rapids, to Dawson. The gold placers of the Klonkyke creeks are fully discussed, with all the deliberation of a sage observer of wide experience. It is by no means that gold forms the only richness of the Arctic region under consideration for specific reference is made to manifold other valuable resources, of particular interest being mountains of iron ore and a great lake of petroleum These and many other interesting features are well pictured in the profusely illustrated pamphlet which is bound to prove enjoyable and profitable reading to all.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity, Gas and Power.

OFFICIAL ORGAN OF THE PACIFIC COAST
ELECTRIC TRANSMISSION . ASSOCIATION.

Subscription Payable in Advance. Terms—Domestic, One Dollar per Year; Foreign, Two Dollars per Year.
Rates for Advertising on Application.

The trade supplied by the San Francisco News Company.

EDITED AND PUBLISHED BY GEO. P. LOW.

Business Office, 22 CLAY STREET
Telephone, Steiner 623.

Address all communications to
Editorial Rooms, 427 TENTH AVE

SAN FRANCISCO, CAL.

Entered as Second-class Matter at the San Francisco Postoffice

Volume V. MAY, 1898. Number 8

EDITORIAL.

AN ELECTRICAL REGIMENT.

Marked recognition is given to the active part that electricity plays in modern warfare by the action of the Secretary of War in calling upon Captain Eugene Griffin, second vice prisident of the General Electric Company and a graduate of West Point, to raise a regiment or brigade of engineers to be comprised of civil, mechanical and electrical engineers, practical electricians, mechanics, draughtsmen and men familiar with all kinds of engineering work. There is a bill now before Congress, already passed by the Senate, for the expansion of this proposed regiment into a brigade, and those possessing proper qualifications in the directions indicated and as are desirous of enlisting can do so by making application to Dr. Thomas Addison, manager of the San Francisco office of the General Electric Company, in the eleventh floor of the Claus Spreckels building.

Applications may be made in writing and in every instance, information must be given concerning the following points: First, name; second, address; third, age; fourth, married or single; fifth, where born; sixth, professional experience; seventh, military experience; eighth, does the aplicant speak Spanish; ninth, experience in the tropics.

The making of application in the manner above indicated will simply signify to Captain Griffin that the applicant has an intention or desire to enlist in the engineering brigade when the proper time comes. No more worthy cause could be conceived and the call should meet with such a response that, in attesting the patriotism of the electrical industry, will enable the Government to enlist the services of the very best talent in the profession in its electrical regiment.

ELECTRICITY ON A MODERN WARSHIP.

Some surprising data appear in an article under the accompanying caption in the current issue of "The Engineering Magazine" under the authorship of Mr. George H. Shepard, which first points out the almost increditable inefficiency of the steam engines used as naval auxiliaries, then discusses the possible uses, defects, efficiency and proportions of an electric plant that would be required to supplant steam for the direct operation of naval auxiliaries, and finally reaches a conclusion that from the reasoning given, the limit to the application of electricity to the auxiliary needs of a modern warship depends upon the future improvements in electrical appliances, especially in the matter of weight.

While the inefficiency of small steam engines, and notably that of duplex pumps, is notorious, one is not prepared for the statement that there are engines in use in the best war ships that are using from 100 to over 300 pounds of steam per indicated horse power, while an average of thirty one of the engines indicated on the "Minneapolis" showed an average of 119 pounds per i. h. p. "In other words," observes the writer, "The data show that at 8 pounds of water evaporated per pound of coal, 5,769 pounds of coal can be saved per hour." Further on, in discussing the increased efficiency that would result from the furnishing of electric power to all the auxiliaries of the "Minneapolis," Mr. Shepard states that "at this rate, the saving to the Minneapolis would be about seventy-five dollars per day in port, and somewhat more at sea," which is assumed to be the average value of the 24,000 pounds of coal that the electric plant would save daily.

It appears from the article that for a first-rate protected cruiser about 1600 i. h. p. would b allowed for the auxiliaries, and for a heavy battleship, about 2,400 i. h. p.; but with an assumed load factor of fifty per cent., an electric power plant for the auxiliaries of a battleship must consist of at least 1,200 i. h. p., requiring dynamos that, with an efficiency of 82 per cent. for engine and dynamo, and 88 per cent for motors, will be capable of developing 1,014 kilowatts. Under present naval regulations the potential is restricted to 80 volts and it is impracticable to install generators having a current capacity in excess of 1,000 amperes for a dynamo, hence it would require thirteen dynamos to give the necessary power at 80 volts. It is impossible to find room on a battleship for thirteen such dynamos. Should the regulations be modified so as to permit the use of 220 volts, it might be possible to find room to install the five dynamos required, together with the sixth generator set that is required to bring the reserve up to the required 30 per cent. These six generators, which must be direct connected to independent engines will weigh 524,000 pounds if operated by simple engines, or 440,000 pounds if operated by compound engines; the weight of motors required to supply the 2,400 horse power for all the auxiliaries would be 241,650 pounds, making the weight of engines, dynamos and motors 681,650 pounds, which is almost exactly three times that of the present steam system.

Electricity then possesses every advantage as to efficiency, economy, and desirability for supplanting steam in the operation of naval auxiliaries, but despite these advantages, which are almost universal paramount, its use in this direction is impracticable at present simply because it requires the weight of the auxiliaries to be multiplied by three. The force of this argument will be understood when the fact is appreciated that war ship design is a constant struggle to save weight in order that the war vessel, on a given displacement, may have the speed, protection and offensive power to enable her to meet and conquer any vessel of her class; and therewith, the more coal endurance the better.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

MEASURING THREE PHASE CURRENTS.

The Hanover Polytechnikum has adopted a method of measuring three phase currents that is simple and economical of instruments and of time required. It is moreover, applicable to both the star and delta systems. Indicating the three wires by the letters A, B and C, the power in both systems in equal to the voltage between A and B multiplied by the current in C, plus voltage between A and B multiplied by the current in B.

An illustrated description of the method appears in the London Electrical Review for December 10th, 1897, in which is diagramatically shown the arrangement of a switchboard with permanent connections for making these readings with ease and facility.

COAL AT FIVE CENTS A POUND.

The Consolidation Coal Company, whose mines are on the Baltimore and Ohio Railroad near Cumberland, Md., ship considerable coal to San Francisco for smithing purposes, and the cost of the coal at the mines and the price at which it is sold to consumers in certain parts of California has developed an interesting situation with reference to transportation charges.

The company gets 85 cents a ton for the coal at the mines, and then it is sent over the B. and O. to Locust Point, where it is loaded on vessels and goes around the Horn to San Francisco. From there it is shipped by rail to the interior points and then placed in sacks and carried on mules to the small mining settlements scattered through the mountains. This coal is retailed in these settlements, in some of which being hundreds of miles from the railroad, it sells at 5 cents a pound, or at the rate of $100 a ton.

SAND POWER FOR MINING PURPOSES.

Mr. L. B. Andrews recently discovered some rich stringers of gold bearing quartz between Death Valley and Shadow Mountain, in San Bernardino county, Cal., but being far out in the desert, he was, for a time, nonplussed as to means for milling and marketing the ore. Considering the distance to railroad transportation, he deemed it out of the question to ship his ore at a profit. Wood and timber there were none, and only sufficient water for camp purposes and an arrastra. No feed in sufficient quantity for animals was to be had, and it began to look as though Mr. Andrews would be forced to abandon his find.

"I was about to pull up stakes and break camp," said he, "when an idea struck me, and I determined to carry it out. The section in which I am located is particularly sandy, and the wind blows at times with great velocity. I thought that a means could be devised for utilizing both. To think was to act, and I proceeded at once to secure the necessary material for my plant. I first built an immense bin, capable of holding many tons of sand. Below this bin I erected a large overshot wheel, gearing from the wheel to an 8-foot arrastra, which I had constructed. Alongside the sand bin I also erected a windmill, and to this I geared a line of elevator buckets, each bucket capable of holding about ten pounds of dry sand. After I had completed the work, I turned my wind-mill loose. The buckets would take the sand and pump it into the bin; from the bin it found its way to the overshot wheel, and from the wheel I derived abundance of power with which to run my arrastra. I have a calm once in a while, but as my bin is capable of holding a large surplus of sand, so for I have been able to run continuously, with the exception of a few hours, and with proper regulation I do not think I would have lost that time. Had I sufficient water for milling, I am confident that I could keep a 5-stamp mill going with my sand power. I have now had my arrastra working continuously for fifty-two days and nights, and am pleased with my new power. I have not found it necessary to make any repairs, except for the first few hours in starting, and since then everything has worked like clock-work."

Mr. Andrews showed as an evidence of his first work a 42½-ounce gold brick, valued at about $750. He proposes to at once take out letters patent on his new device, as he believes that ere long the power will be in general use throughout all the desert sections.

Transmission

SOME DATA OF A 30,000 VOLT LINE.

SOME interesting experiments with high voltages on the power linese of the Yuba Power Company's Plant, which has just been completed near Marysville, Cal. were made early during the present month. These experiments were conducted by Dr. F. A. C. Perrine and some of his senior students from Stanford University, assisted by Messrs. Theo. E. Theberath of the Stanley Electric Company and Frank Vanatta of the Yuba Power Company.

A description of this Plant will be found elsewhere in this issue, and particular attention is called to that part which deals with the pole line construction. Briefly, the pole line consists of two four wire circuits arranged side by side on the same poles extending from the power house to a junction pole distant about six and one-quarter miles, from which place what is known as the Brown's Valley circuit, extends about three-quarters of a mile further to the Brown's Valley mines, making the total length of the four wire circuit about seven moles. The line is built throughout of No. 6 B. & S. medium hard drawn copper wire, secured with the new Western Union tie to 5½ in Locke annealed glass insulators, which are secured to the cross arm by means of steel pins having locust wood tops and porcelain bases. The pins and cross arms are coated with two coats of P. & B. paint.

For the purposes of the test the wires of each phase were connected in series at Brown's Valley, making a two wire single phase metallic circuit fourteen miles in length and in this way both ends of the circuit were controlled at the power house. The normal initial voltage of this line is 16,700 volts, and for the purpose of the test two transformers having a ratio of 2300 to 16,000 volts were connected in series and used as step up transformers with two other transformers connected in like manner used as step down transformers. All of these being located at the power house.

Some preliminary experiments that were made showed that when an e. m. e. of 30,000 volts was placed on the line, some wires in the Brown's Valley sub-station, which are not more than 2¾ inches apart, would short circuit or arc across, the arc travelling along the wires for some distance until it reached a place where the wires widened out and the arc could no longer maintain. As soon as the arc was broken the line would short circuit as before. This section was then cut out and the connections arranged so that the wires were in no case distant less than eighteen inches from each other. After this had been done the potential was carefully raised to 30,000 volts and held there until reports from observers, who were stationed at intervals along the line, were received. At this time, and under these conditions, the switchboard ammeters showed that the line current was about 2¼ amperes, with the ends of the line open and without the step down transformers being connected in. This current being the charging current of the line but representing little expenditure of energy.

After these observations had been taken the step down transformers were connected to the line and the voltage again raised, the potential reading at the ends of the line being approximately 29,500 and 29,220 volts, under which conditions the line current was 2.08 amperes. Raising the potential to 31,500 volts gave a reading of 2.12 amperes which compared with the reading on the open line shows the effect of added self-induction in increasing the line current.

THE MARTIN SWITCH BREAKING 30,000 VOLTS.

The drop in the voltage observed indicated that the fall of potential over the line was in the neighborhood of 250 volts though the C. R. drop itself would account for only 95 volts, calculated on the basis of the current and resistance of the line, the remaining 185 volts being chargeable to line inductance and capacity.

No artificial load was applied to the line as it was found that when a voltage of 30,000 volts or more was impressed on the line, a leakage occurred across the back of the high potential switchboard in the power house. This leakage was partly due to the roughened surface of the marble and also to the fact that the board was designed for operation at 16,000 volts. When this leakage occurred it was evidenced by very loud reports; and as the plant at the time of the test was providing light and power service in Marysville, it was not deemed advisable to risk a dangerous short circuit on the station board due to the increase of the load at a potential 30,000 volts.

The "Martin" high potential switch which is used on the high potential side of the transformers at this plant, was thrown at a time when the potential was as high as 30,000 volts. Although the arc was very vicious, (as is shown by the accompanying photograph) it was successfully broken, and the line opened without any difficulty by the aid of the switch. Notwithstanding the nature of this arc, on a close examination of the switch being made, no burning of contacts or other evidences of the powerful arc over three feet in length was developed, demonstrating that the switch could be used, with but slight modifications, for voltages as high or even higher than those used in these experiments.

Voltages as high as 34,000 were read on several occasions and once almost 36,000 volts was impressed upon the line, but no readings of current, etc., were then taken, as it had not been originally proposed or preparations made to experiment with potentials as high as this.

Along the line during the test, no static discharges or illumination of the line were noticed at any time, although careful watch was kept by observers stationed at different points along the pole line. These observers were all equipped with telephones so as to enable them to communicate with the power house at all times. This absence of static discharge and the so-called phosphorescence said to be noticeable on high voltage lines, was remarkable in view of the experience of others and particularly in view of the experience of the Utah plant when a similar test was made.

The experiments demonstrated conclusively the practicability of using voltages much higher than those at present in use or contemplated with but a very slight modification of the line insulation, transformers and generators already on the market.

THE DINGLEY BILL IN HANDY FORM.

The American Protective Tariff League has just issued another and very complete edition of our Tariff laws. This volume of 144 pages, gives the official text of the Dingley Tariff; complete comparison of the Dingley and Wilson law; and, index to all articles covered by the new Tariff. The book will be of great value for reference and for answering all questions regarding the Tariff question. It will be sent to any address for 25 cents. Ask for document No. 27, and address the American Protective Tariff League, 135 West 23d street, New York.

Educational

ALTERNATE CURRENT WORKINGS

By Donald H Fry.

Part iii

THE CALCULATION OF POLYPHASE CIRCUIT FUNCTIONS.

EVERY wire carrying an electric current is surrounded by a magnetic field which varies in strength with the current causing it. Undisturbed by any opposing field the magnetic lines of force pass around the wire in circles, the planes of which are perpendicular to the wire, and the direction of which is the same as the direction of rotation ot an ordinary right hand screw when the current is flowing in the direction of the point of the screw. This may be seen in fig. 17, which represents the cross section of a wire and its surrounding field; the current is supposed to be flowing away from the observer. If two wires are run parallel, one carrying a current, the second will be undisturbed by the field of the first so long as the current is constant and its field stationary, but if the current vary, these magnetic circles expand and contract as the current is increased or decreased, and so the second wire is cut by them and consequently an electromotive force is set up in the wire just as though it were moving in a stationary field. If the second wire carries the return current of the first, the two affect one another and the value of the electromotive force set up is doubled. In an alternating current this induced electromotive force follows 90 deg. behind the current and is the *self-induction* of the line, causing a *reactance* which acts in much the same way as the ohmic resistance of the wire except that the resistance directly opposes the flow of current while the reactance opposes any change or variation in the flow. Thus the resistance and the reactance act at right angles to one another and their resultant is called *impedance*, which is the total opposition to the current; its value is $\sqrt{R^2 + S^2}$ where R is the resistance and S the reactance.

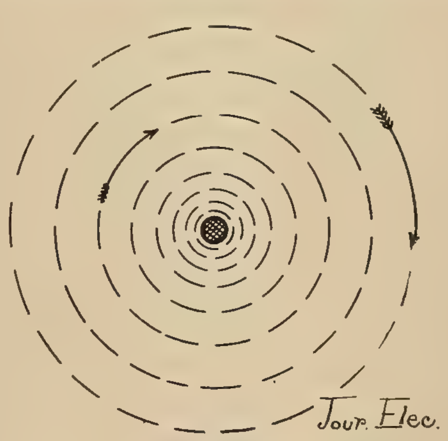


FIGURE 17.

The reactance of a line varies with the size of wire, the distance between wires, the frequency of the system and also the curve the current follows. The accompanying table of the reactance and impedance of various sized wires is calculated from the equation

$$S=\frac{2\pi f}{10^9}\,(9.2\ \log\frac{d}{r}+1)l$$

where l is the length of the line in centimeters and $\frac{d}{r}$ the ration of the distance between wires to the radius of the wire. This equation is based on the assumption that the current follows a sine curve; for a saw tooth or a peaked curve the values would be slightly higher. The frequency 60 is chosen because it is the most common in power-transmissions, but for any other frequency the values may be derived from the accompanying table by multiplying the figures in the reactance column by f/60.

Thus suppose it is desired to find the reactance and impedance of a circuit of No. 2 wire with conductors 18 inches apart and carrying a current alternating at a frequency of 125 alternations per second. At frequency 60, the reactance per mile is 1.260; at frequency 125 it is $1.260\times\frac{125}{60}=2.625$, and the impedance is $\sqrt{(1.662)^2+(2.625)^2}=3.169$ ohms per mile.

GAGUE NO. B. & S. WIRE	RESISTANCE OHMS PER MILE	DISTANCE BETWEEN WIRES IN INCHES	FREQUENCY=60	
			Reactance	Impedance
0000	.521	18	1.119	1.234
		24	1.189	1.298
		28.3	1.228	1.334
000	.657	18	1.148	1.323
		24	1.217	1.383
		28.3	1.257	1.418
00	.829	18	1.176	1.439
		24	1.245	1.496
		28.3	1.285	1.529
0	1.045	18	1.204	1.594
		24	1.272	1.647
		28.3	1.313	1.678
1	1.318	18	1.230	1.803
		24	1.300	1.851
		28.3	1.341	1.883
2	1.662	18	1.260	2.085
		24	1.330	2.129
		28.3	1.369	2.153
3	2.096	18	1.288	2.460
		24	1.360	2.498
		28.3	1.400	2.525
4	2.643	18	1.315	2.952
		24	1.385	2.984
		28.3	1.425	3.003
5	3.332	18	1.344	3.593
		24	1.413	3.619
		28.3	1.454	3.635
6	4.202	18	1.373	4.424
		24	1.441	4.442
		28.3	1.482	4.456
7	5.299	18	1.402	5.481
		24	1.470	5.499
		28.3	1.510	5.510
8	6.682	18	1.428	6.833
		24	1.498	6.848
		28.3	1.538	6.857

If a third wire is parallel to the two wires of an alternating circuit, it will be affected by them both unless it is equally distant from the two, for then the inductive effect of the one neutralizes the inductive effect of the other. This can readily be seen without mathematical proof when it is remembered that the value of the current in all parts of a circuit is identical, but the flow in the two line wires is in opposite directions thus causing opposing fields which will exactly counter balance one another at all points equi-distant from the two wires. If *a b*, figure 18, are the wires of an alternating circuit, a third wire *c* anywhere on the line bisecting the line *a b* and perpendicular to it will have no induced electromotive force set up in it. In a like manner it is seen that if there are two complete circuits *a b* and *c d*, neither will affect the other if the wires of one are equi-distant from the wires of the other, and this is made use of in two phase power transmissions where the wires are run in a square, the phases forming the diagonally opposite corners. The wires of each phase will still affect one another by self-induction,—that cannot be overcome—but the disturbing influence of one phase upon the other, or the mutual induction is eliminated. The mutual induction of a three wire transmission is also overcome by arranging the wires in the corners of an equilatteral triangle.

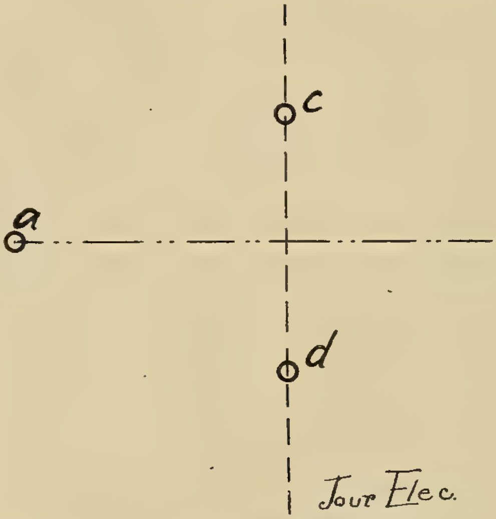


FIGURE 18.

It might be well to explain the calculation of a transmission line and the use of the above table by an example. Assume a 100 kw. two mile transmission employing a two phase system with a frequency of 60. The current is to be delivered at 2,000 volts, and we shall further assume the load to consist of lights only and therefore practically non-inductive. If the load is balanced, each phase will transmit 50 kw. and the current in each phase will be $\frac{50000}{2000}=25$ amperes. Deciding on a line loss of 4 per cent, the loss in watts for one phase will be 2000. As C=25 and $C^2R=2000$, R, the resistance of the line is 3.2 ohms or 1.6 ohms per mile of line. The resistance of No. 2 wire is 1.662 ohms for the mile of double wire, which is close enough. As stated above, to overcome the mutual induction of the two circuits the wires should be run in a square with the phases forming the diagonals, so if the wires are 20 inches apart there will be 28.3 inches between the wires of a phase, and from the table we get the impedance of No. 2 wire, which is 2.153 ohms per mile or 4,306 ohms in this case. The drop will be 4.306 × 25 = 108 volts and so the voltage at the generator must be 2108 volts. In this instance, the *line loss* is approximately 4 per cent but the *line drop* is nearly 5½ per cent.

When the current lags appreciably, as is almost invariably the case with a motor load, it is not such a simple matter to ascertain the loss and drop in a line, but an approximation can be derived in the following manner. Assume a 1000 kw. 10,000-volt, three phase-power transmission, the length of the line to be ten miles and the frequency employed 60. The power factor of the load, which is to consist of motors and lights combined we shall assume to be 90 per cent. Furthermore we are to step up from the machines to the line at a ratio of 1 to 5 and step down again at the sub-station at the further end of the line at 5 to 1, the pressure at the secondary terminals of the step down transformers to be 2000 volts. We may further assume a copper loss of 1 per cent, a hysteresis loss of 1 per cent and a magnetizing current of 4 per cent in both step up and step down transformers. Deciding the total loss in the transmission is to be 10 per cent with the assumption that the loss in both sets of transformers is 4 per cent (the magnetizing current is 90 degree ahead of the secondary voltage and is therefore entirely wattless) this will leave 6 per cent for the line loss. The current in the step-down secondary, or the load current is, with a power factor of 90 per cent $\frac{1}{3}\times\frac{1000\,000}{2000\text{x}\ .9}=185.2$ amperes per phase, and this would give, neglecting magnetizing current and all losses, $\frac{185.2}{5}=37.04$ amperes per phase in the line. To this we must add 1 per cent to make up for the iron or hysteresis losses of the transformer, and also account for the 4 per cent magnetizing current.

Let *OE*, figure 19, represent the secondary voltage, and *OC* the current lagging behind by the angle φ. In this case cos φ, the power factor is .9 At right angles to *OE* draw *OA*, in length .04 times *OC*; this is the magnetizing current multiplied by the ratio of transformation, and in phase is 90 deg. ahead of *OE*. The length *CA*, the resultant of *OC* and *OA*, is 1.018 times *OC*, sa the current in the line will be 37.04 × 1.01 × 1.018 = 38.08 amperes. To derive the current and the generator voltage, we must again multiply the line current 38 08 by 1.01 and by 1.018 and this product by 5, the step-up ratio, which gives 195.7 amperes as the curent per phase. As each wire of the line carries the current of two phases 120 degrees apart, the current in the wires will be $38.08\times\sqrt{3}=65.9$ amperes. Since the C^2R loss in the line is to be 6 per cent, the loss in each wire will be 2 per cent or 20,000 watts, and as C is 65.9, *R*, the resistance of each wire will be 4.6 ohms or .46 ohms per mile. Our choice of wire then lies between No. 00 and No. 0. Deciding on No. 0, as that is nearest, gives the resistance drop of the line of 10 miles of double wire to be 65.9 × 10.45 = 688 volts. The reactance of the line, if we space the wires 24 inches apart will be 12.72 ohms. Only the current in one phase causes a reactive drop so this is derived by multiplying 38.08 by 12.72 which gives 484 volts. In ascertaining the action or effective voltage of the load from the current, that part of the current which is used to make up the iron losses must not be included. The value of the current will be 37.04 × 1.018 × 1.018 = 38.37 amperes, and as each phase is to transmit 333333 watts the effective volts will be $\frac{333333}{38.37}=$ 8687. The reactive voltage due to the inductance of the load and the transformers will be $\sqrt{\{(10000)^2-(8687)^2\}}=4953$ volts. The copper or C^2R loss in both transformers is 2 per cent of the work of one phase or 6667 watts. This is made up of the primary and secondary and leakage losses of both step-up and step-down transformers, but as it merely causes a drop in the secondaries, we may roughly count C the line current which will give the effective volts drop 175. The total effective volts will be 8687 + 688 + 175 = 9550 and the total reactive volts or wattless volts = 4953 + 484 = 5437. The total volts impressed at the generator will be $1\text{-}5\sqrt{\{(9550)^2+(5437)^2\}}=\frac{10990}{5}=2198$ volts. The power factor of the total transmission is equal to the effective volts divided by the total impressed volts, which gives in this case 86.9 per cent. The total volt-amperes at the generator is 2198 × 195.7 = 430,150. The watts are obtained by multiplying the volt-amperes by the power factor or 430150 × .869 = 373800 watts. The efficiency of the total transmission is $\frac{333\,333}{373800}=.892$ or .89.2 per cent.

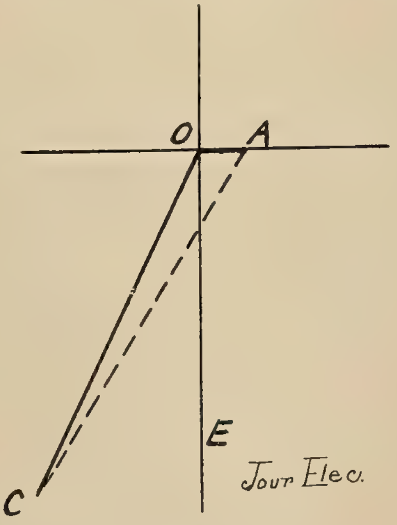


FIGURE 19

The *capacity*, or condenser effect of the line is still to be considered. Every alternating circuit is more or less affected by the capacity of its line wires tending to give the current a lead over its electro-motive force, but where the voltage is not very high, this may safely be neglected.

The capacity cannot be determined exactly beforehand, for although a very close approximation can be obtained from a formula given by Steinmetz, of the General Electric Company, when the length of line, the size of wire and the distance between wires is known, still there are other factors in the problem such as the climatic conditions, height from the ground, and atmospheric pressure; and also, the form of the current wave makes a difference. If K denote the capacity in microfarads; l, the length of transmission in miles; and d/r the ratio of the distance between wires to the radius of the wire, the formula is $K = \frac{.0192\, l}{\log.\left(\frac{d}{r}\right)}$ This will give the capacity of the line to be .0885 microfarad and from the formula $c = 2\pi f E K$, the charging current c is found to be 0.3 amperes. This would slightly reduce the value of the current and increase the power factor, but is too small to affect the efficiency of the transmission appreciably.

One of the larger electrical manufacturing companies recently published a phamphlet on "Alternating Current Machinery"—a reprint of a series of articles that appeared in an eastern electrical publication in 1896. It is an estimable article and well written, but there is certainly room for criticism of the manner in which the writer (he does not sign his name) calculates a transmission line. Purposely the figures in the above approximation were taken the same as his in order to compare results, and it is a wonder the discrepency between the two is not even larger.

In the first place his line is to be a 10,000 volt three-phase transmission, yet the phamphlet states that "the difference of potential between any two conductors will be $\frac{10000}{\sqrt{3}} = 5{,}775$ volts." Why? In speaking of a 10,000-volt transmission it is usually meant that the difference of potential between the two wires is 10,000 volts, but suppose it is the transformers that give 10,000 volts? Then if they are connected △ the difference between the line wires is 10,000 volts, while if they are connected Y^2 the difference would be $10{,}000 \times \sqrt{3} = 17{,}320$ volts.

But in the next move the author gets on his feet again. "Consequently," he goes on to say, "the energy current for each phase, that is, in each conductor, will be 58 amperes, since each phase is to supply 333 kw." Now unless the transformers are connected Y, the current in each phase and the current in each conductor are not the same, for each conductor carries the current of the two phases to which it is connected and as these currents are 120 deg. apart the total current in each wire is $\sqrt{3}$ times the phase current. To correct one mistake by another is hardly legitimate, yet by this means he derives an approximate value for the current and so gets the right sized wire, No. 0.

Further, the writer referred to goes on to state that "the reactance of No. 0 wire at 60 cycles per second is seven-tenths of an ohm per mile, or seven ohms in this particular case." Aside from the fact that .7 is rather a low estimate for the reactance, it might well be objected that the reactance of a certain sized wire has not a fixed and definite value, for the distance between the wires has as much to do with the reactance as the size of the wire. To illustrate this, the reactance of No. 3 wire, 18 inches apart, is the same as that of No. 00 28.3 inches apart, or the reactance of No. 8 wires run 10 inches apart is approximately the same as No. 0 at 24 inches. In order to derive the reactive drop he multiplies the reactance, 7 ohms, by the value of the total current in the conductor when the reaction of self-induction can only be due to the current in one phase, but his low estimate of the line reactance again counterbalances the mistake, and so he goes serenely on and after calculating the apparent efficiency and calling it the power-factor, he tackles capacity and the effect of harmonics, subjects that will hardly stand treating on "the percentage method." In fact with the exception of the first error most of his mistakes are mainly due to treating all losses as percentage losses, a method which is very confusing and at best unsatisfactory.

Any attempt to entirely eliminate mathematics from alternating currents must necessarily result in failure. Reasoning *a priori* is not permissible, and to solve problems without the aid of at least the elements of mathematics is an inherent impossibility.

"Congratulations on the pretty paper you are turning out."—Geo. H. Guy, New York City.

CONSOLATION.

When the rash contractor waileth for the work that has gone wrong,
  When he weeps to know that the profession know it;
O, let him sweet nepenthe seek in this consoling song,
  And if he feels like swearing, simply "blow" it.
For though his name may raise the jest among those in the know,
  And though his stock may swell and make him tearful:
It's a very, very evil wind that good to none doth blow,
  And his trade competitors will feel more cheerful.

When Demon Fog is choking us, when black the air and sour,
  When life is dark and dismal as a prison,
When speech is blindly sulphurous as fumes which overpower:
  O, think what lovely load curves have arisen!
And sense the joy of station chiefs and those who hold the scrip
  Of lighting works: you bet there's no repining;
For if there's silvery edging to the cloud, you take my tip,
  To the fog there is an eighteen-karat lining.

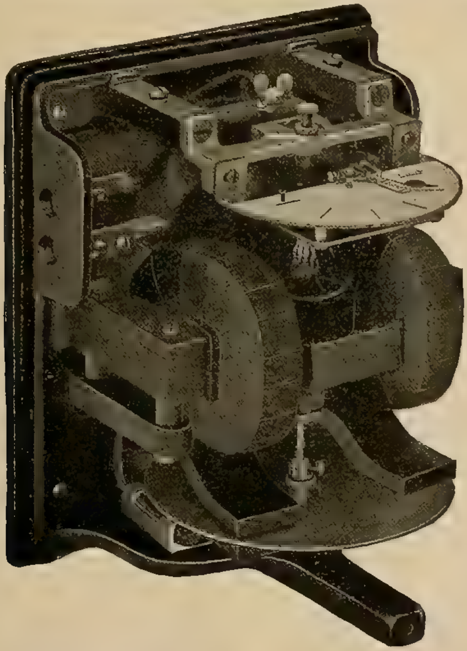
Ho, all you central-station men who work the mid-day shift
  On Saturday, the 25th of December,
Refrain from letting feelings into profanation drift
  Because of this; but thankfully remember:
That turkey's indigestible, mince-pies would make you ill
  (The fox that hated grapes may serve as warning),
You'll miss the black draught afterwards, you'll miss the loathly pill,
  And you'll miss the going to service in the morning.

—"J. H. C. B." in London Electrical Engineer.

A STORAGE BATTERY WATTMETER.

The increasing application of storage batteries, consequent on their perfection, to electric light and railway station use, as well as to street cars, motor carriages, electric launches, etc., where a portable source of power is requisite, has led to the development of a special type of the Thomson recording wattmeter which will show at a glance the amount of energy available in the battery. Their new Thomson recording storage battery meter, as it is called, resembles in general appearance, the standard Thompson recording wattmeter, and is, in fact, a development from it, the mechanism being almost exactly similar. The accuracy and durability characteristic of the standard type have both been maintained, while additional precaution is provided with a single indicating needle moving over a horizontal semi-circular dial.

The essential requirement for a storage battery meter is that the armature shall rotate in either direction and give equally accurate readings in both. In this meter this requisite is fully preserved. The energy put into the cells, is, therefore, added to the reading of the meter, while the energy withdrawn is subtracted, but to compensate for the loss in the cells the meter runs more slowly when charging. The reading of the meter represents not the amount of energy put into the battery, but the amount available and when the needle points to zero on the dial it shows that the battery is completely discharged.



For motor carriage, street car and electric launch service a meter of this charater is a most necessary adjunct. Indeed, any of these vehicles of transportation not equipped with a device to warn the operator of the amount of current available to carry him forward on his journey or to bring him back to his starting point, would be incomplete. Without it he is absolutely ignorant of the power upon which he can depend, and would run serious risk of finding himself at a stand still far from home with no means of getting either forward or backward without recourse to some mechanical method.

The durability and efficient operation of storage cells being maintained by re-charging them before they are exhausted, the only method of learning of their exact condition is by a meter ofthis character. The cells being recharged at the right time, thegeneral result is a much higher battery economy.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

MR. J. W. BROOKS RETIRES.

The Brooks-Follis Electric Corporation has issued the following self-explanatory announcement under date of April 30th, 1898:

"We beg to inform you that, from May 1st, 1898, the management of the Brooks-Follis Electric Corporation will be under the charge of Mr. Thomas H. Van Frank, as manager, business interests in the East compelling the retirement of Mr. John W. Brooks.

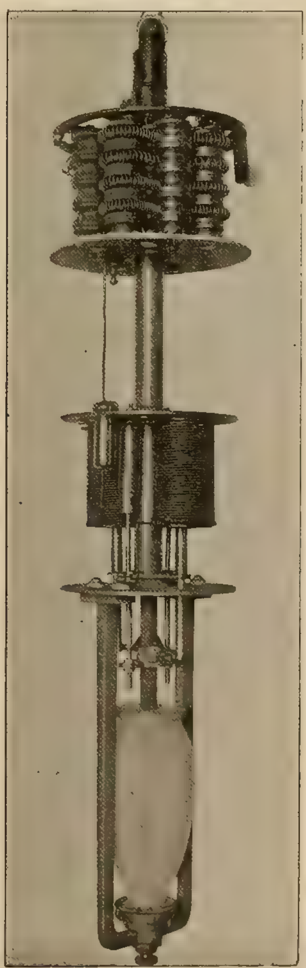
"We trust that you will extend to us, under the new management, the same valued consideration as in the past.

"Very truly yours,
"BROOKS-FOLLIS ELECTRIC CORPORATION.
"Jas. H. Follis, Pres."

A PERFECTED ENCLOSED ARC LAMP.

Since the introduction of the enclosed arc lamp, the large quantities used and the positive endorsement of Central Station operators of large experience has been so marked that but little need be said comparing it with the lamp of the open arc principle. which is rapidly becoming obsolete.

The life of the carbon has been increased fifteen times over the open arc, which means increased economy in material and attendance. Although it is advisable to use an imported carbon in the enclosed arc lamp, the cost of carbon renewals in the Pacific Arc Lamp is less than incandescent lamp renewals for the same amount of light. ....



The inner globe which entirely surrounds the arc, acts as a perfect spark arrester; this feature of perfect safety from fire has caused the enclosed type of arc lamp to be endorsed by all boards of Fire Underwriters. The inner globe also renders the consumption of the carbon perfect and noiseless, doing away with the objectionable and annoying "hissing" of open arc lamps.

The potential on which an open arc lamp operates is from 45 to 50 volts. The principle of the enclosed arc lamp permit of it being operated singly on a circuit of from 95 to 125 volts; thus the wiring connection of the lamp to a circuit is much simpler and allows the lamp to be turned on or off independently of any other; in fact, to be installed and operated similar to an incandescent lamp.

The Pacific arc lamp, type "A," is designed to burn singly across a direct current circuit of the voltage above given at a current consumption of 4 to 6 amperes; or two arc lamps may be burned in series across a circuit from 190 to 250 volts. but unless otherwise ordered, lamps will be adjusted at the factory for a current consumption of 4½ amperes at a voltage of 110.

The canopy is made in polished brass finish or black enamel, the latter being recommended and it may be used for either indoor or outdoor service, for the latter the top of the canopy is covered by a small water sheeding shield or hood. It may sometimes be necessary to get at all the internal parts of the lamp; particular attention therefore has been given to the design of the canopy that it may be removed easily and quickly, entirely exposing the lamp's mechanism. For hanging the lamp by a cord, an insulated screw cap is provided, which can be removed if the lamp is to be screwed to a stiff metal drop.

A potential of from 70 to 80 volts is maintained across the arc. In the upper portion of the canopy is the resistance coil and by cutting in or out the proper amount of resistance by suitable clips the lamp may be adjusted to burn on a circuit of from 95 to 125 volts.

Two globes are employed, one inside the other. The inner globe of special glass surrounds the arc, and is capped at both ends; complete combustion of the carbon being obtained by the admission of the proper amount of oxygen. The outer globe is a ball 12 inches in diameter, with 5-inch opening on top, entirely closed on the bottom. This globe is supported by the canopy, no lower metal support being used, hence all possible light is obtained directly underneath. A metal ring is permanently attached to the neck of the globe by thumb screws; this ring engages in the canopy by a clip, thus the globe may be easily and quickly removed without loosening the thumb screws. Chains of suitable length support the globe while the lamp is being trimmed. As a result of long experiments, the use of an opalescent inner globe and light frosted outer globe is recommended as giving the purest and finest light.

The mechanism of this Pacific arc lamp is unique and differs radically from anything on the market and its remarkable simplicity and fewness of parts recommend it strongly. It is of the lever clutch feed type; the clutch being entirely insulated from all parts,, hence no arcing is possible between it and the carbon. No carbon rod is used. No gearing or wheels or set screws are employed. The arc is broken magnetically and fed by gravity, and being inclosed there is no liability to accident from insects or accumulation of dust.

No springs are used, as it is well known that the resilience of a spring is affected by changes of temperature, for which reason the adjustment of lamps using springs is difficult and very unsatisfactory as a fixed temperature cannot be maintained. The Pacific arc lamp is therefore independent of temperature changes and on one trimming, the lamp will burn about 150 hours. Special imported carbons are employed, the upper carbon being 12 inches long, and the lower carbon 6 inches long, both carbons being one-half inch diameter.

In recapitulation, the Pacific arc lamp has no set screws to maintain adjustment; it has no carbon rod, no springs, no wheels, or gearing, and no shadows. The lamp has the fewest parts of any lamp made, it is of graceful design, perfect in workmanship, produces a perfectly steady light and is easiest to trim of any on the market. It is moreover, the finished product of a purely California concern, well deserving of patronage.

Manufactured and for sale by the Pacific Arc Lamp Company, 23 Stevenson street, San Francisco.

A TREATISE ON LIGTHNING ARRESTERS.

"Lightning Arresters," is the title of a short treatise from the press of the General Electric Company, descriptive of the devices which it has developed for preventing injury to electrical aparatus by lightning. The introduction is a short examination of the qualifications necessary to a perfect lightning arrester, with a short disquisition on the special advantages of the magnetic blow-out. This is followed by concise descriptions of the arc and incandescent station arresters, already well known as types "A," "AA" and "B." Greater space is given to the more recently developed lightning arrester for direct current circuits up to 850 volts, and to the G. E., short gap arrester, especially designed for alternating current circuits and in use on almost all of the great electric power transmissions of the West. The booklet is well written and printed, the illustrations are excellent and the diagrams of connections clear and distinct. We understand that "Lightning Arresters" will be furnished by the Supply Department of the General Electric Company on application at any of the sales offices.

TABLE OF CONTENTS.

Illustrated articles are indicated by an asterisk (*)

*The Yuba-Marysville Transmission.. 145
*Some Experiments at 30,000 Volts. 162

Editorial

The Salesman of the Future.. 160
Electricity in Modern Warefare. 160

Passing Comment

Measuring Three Phase Currents.... 160
Coal at Five Cents a Pound.. 160
Sand Power for Mining Purposes.... 161

Personal

Bly, Leon W..... 159
Stockdale, James T... 159
Stuart-Smith, Lieut. W..... ... .159

Miscellany

Alaska as it is.. .. ..
*A Storage Battery Wattmeter.. 167

Transportation

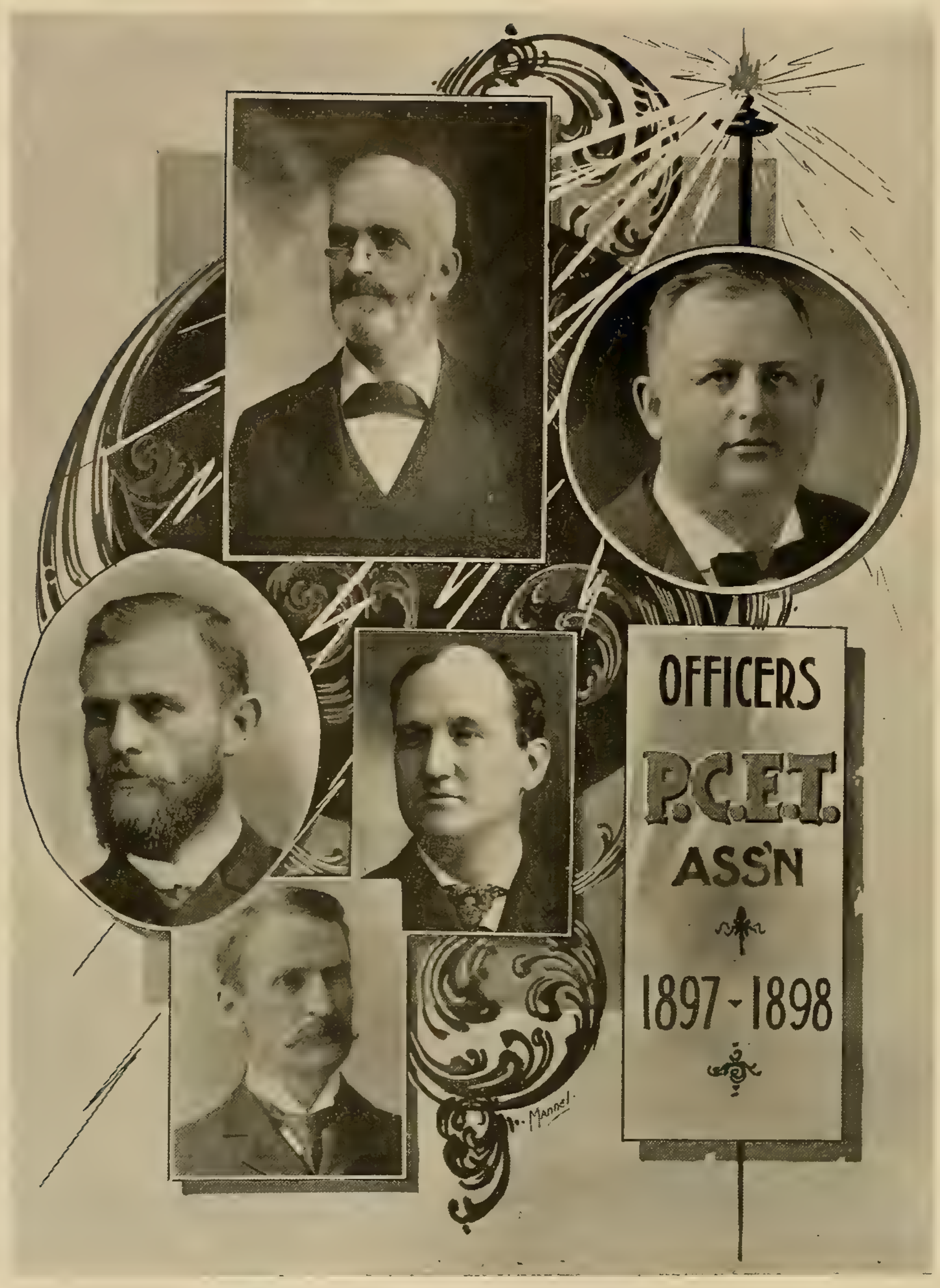
The Third Rail System in a Snowstorm.... 161

Industrial

Mr. J. W. Brooks Retires.... 167
*A Perfected Enclosed Arc Lamp...... 167
A Treatise on Lightning Arresters.... ... .168

Educational

*Alternate Current Wattings, by Donald H. Fry ......
Part III—The Calculation of Poly phase Circuit Functions...... 164
Part I—Alternating Currents. 125
Part II—Poly phase Currents..... ... .128



C. P. GILBERT,
President.

W. FRANK PIERCE,
Member Executive Committee.

ROBERT McF. DOBLE,
Secretary and Treasurer.

H. H. SINCLAIR,
Vice President.

JOHN J. SEYMOUR
Member Executive Committee.

Frontispiece
"Journal of Electricity"
Volume V, 1897-98.

The Journal of Electricity

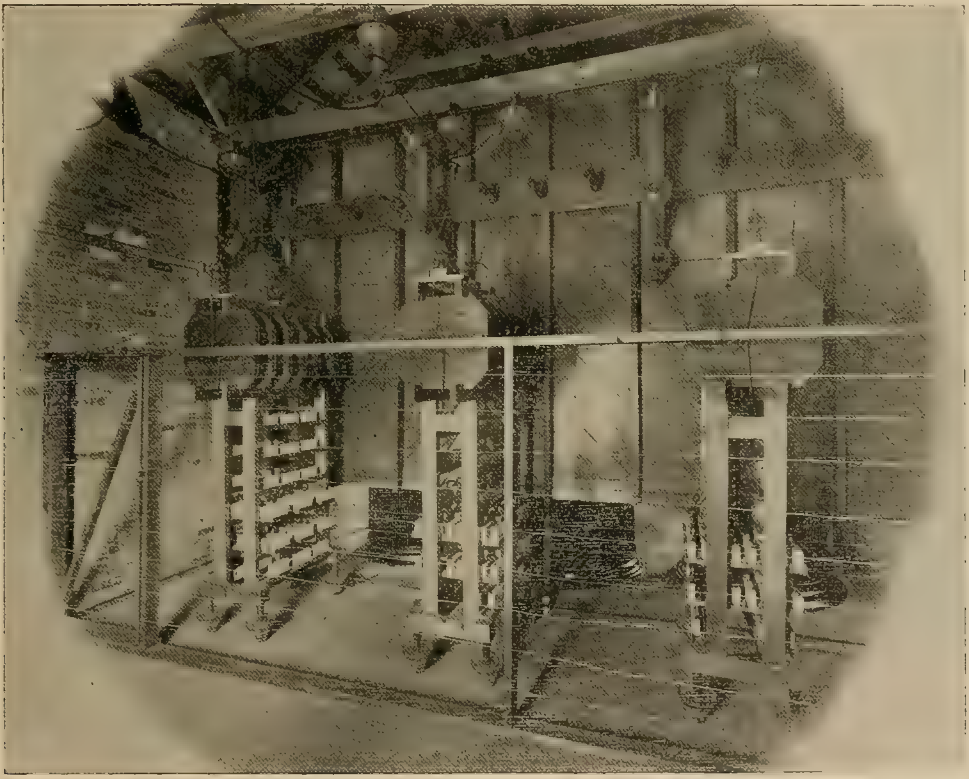
Vol. V. JUNE, 1898. No. 9

The Provo-Mercur 40,000-Volt Transmission

By LEON W. BLY.

BUT few, even in the electrical transmission fraternity, are aware of the fact that the highest voltage employed in the commercial transmission of power over a long distance is that which is now operated on the lines of the Telluride Power Transmission Company between Provo canyon and Mercur, Utah. The Telluride people are pioneers in the field of extremely high voltage transmissions and for several years have experimented conjointly with the Westinghouse Electric and Manufacturing Company, on transmission lines with potentials ranging as high as 120,000 volts.

The line used for carrying out these experiments was a special one extending from the Telluride Company's power house near Ames, Colo., to the Gold King mine and having a length of 11,720 feet. The route of this line was over a rugged country subject to a heavy fall of snow in the winter and rain with severe lightning in the summer. The poles were placed one hundred and eighty feet apart and supported three circuits of No. 8 galvanized iron wire. Practically all the different varieties of cross arms, pins and insulators to be found on the market were tested as were also many new models of these appliances, devised at the time, and during the test runs, the condition of the atmosphere and of the line in regard to snow, rain, humidity, were carefully noted. Up to the present, the results of these impoatant experiments are reserved and every effort to secure the data deduced has been unavailing.

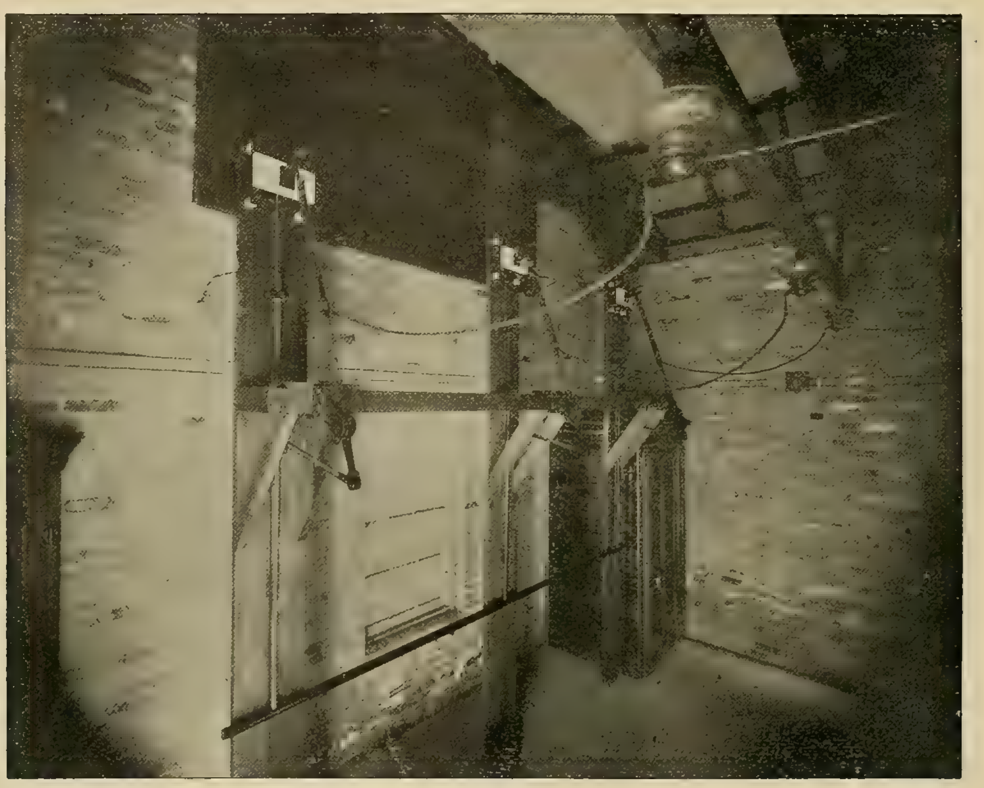


Fuses, Choke Coils and Lightning Arresters on the Provo-Mercur Transmission.

Reverting to the Provo-Mercur transmission, the plans of the Telluride company contemplate the early installation of two thousand horse power, in two units of 750 kilowatts each, to furnish power and lights to the mining interests in and about Mercur and Tintic, Utah. These two districts, which are perhaps twenty miles apart, are respectively thirty-two and forty-six miles from Provo

Canyon, where the power house is located. The Provo-Mercur transmission line is the one which has been placed in operation, but work has been commenced on the construction of the independent line from Provo Canyon to the Tintic district, which will be, as stated, 46 miles in length. After the Provo-Tintic line is completed, the sub-stations at Mercur and Tintic will be connected together by a subsidiary transmission line so that in case of an accident to either main line from Provo, service may be continued without interruption to both places. Immunity from pole line trouble seems to be perfectly secured by this arrangement as the two pole lines take entirely different routes.

At present, one 750 kw. type "A. P." three phase General Electric generator is being operated by a flexible connection to a turbine wheel driven under a head of 125 feet and running at 300 revolutions the turbine being temporarily hand-regulated. This generator has a periodicity of sixty cycles, is star wound, and gives a phase potential of 800 volts. Of the four 250 kw. raising transformers installed in the generating station, but three are in use, the remaining one being as reserve and its connections are so arranged that it can be substituted in service for either of the other transformers at a moment's notice. The normal primary potential applied to the raising transformers is 462 volts, the normal secondary being 23,100 volts. As is the case with the primaries, the secondaries are connected in star, hence the three phase high tension terminals have a phase pressure of 40,000 volts.



Break Switch for 40,000 Volts on the Provo-Mercur Transmission.

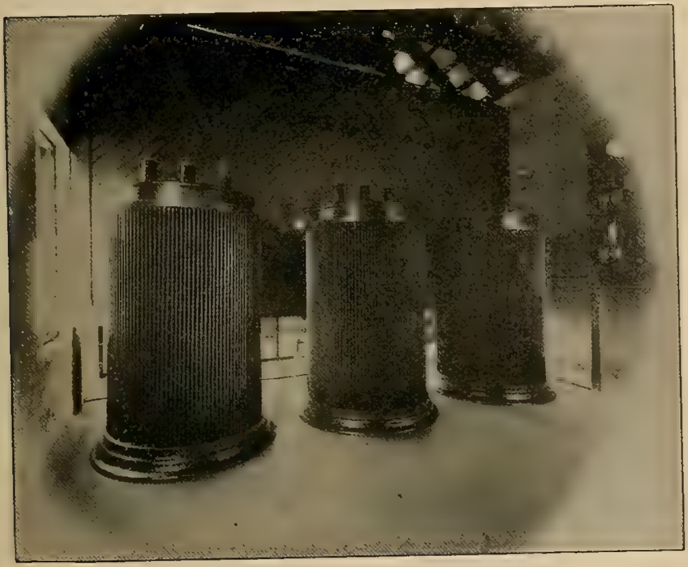
The principal material used in the insulation of these high tension transformers is muslin and fullerboard, blocks of maple wood being used to separate the coils. The transformer cores and coils are immersed in mineral seal oil, with no other cooling device than that of the natural radiation of heat from the surfaces of their cases. This radiation is however, very great because of the fact that the surfaces of the cases is rather deeply corrugated. To be exact, the corrugations are 2½ inches deep and one inch wide. The general appearance of the high tension transformers is shown in the illustration appearing on page 171, which also shows plainly the method of supporting the interior high pressure circuits.

The high tension leads are brought out of the tops of the tanks through walnut bushings on the inside of each of which is a heavy porcelain tube extending from the top of the bushing down into the tank beneath the surface of the oil. The low tension leads are brought out at the sides of the tanks and these low tension leads consist of two series of twenty-eight turns in multiple of two three-quarters inch by 349 mils strap copper. The high tension windings consist of 1400 turns of No. 9 magnet wire. These transformers, as well as the lowering transformers at the Mercur sub-station, were built by the Wagner Electric and Manufacturing Company, of St. Louis, Mo., upon the designs and specifications of the Telluride Power Transmission Company.

Tests made by the writer show the copper loss of the transformers to average about 2150 watts; the iron loss is about 3030 watts; the normal temperature at full load is 118 degrees above that of the surrounding air.

Three phase generation, three phase transmission and two phase distribution constitutes the scheme of the polyphase equipment, and all the three phase portions are star-connected and the common center or neutral point of the star is grounded as shown in the circuit diagram of connections on page 172. Moreover the two phase distribution is grounded as will be described later. The line is protected by the Wurts non-arcing lightning arresters.

The line, which is carried on 35-foot cedar poles placed 125 feet apart, is of No. 5 B. & S., medium hard drawn copper supported so as to form the points of an equilateral triangle having six-foot sides. One of the three wires is placed on top of the pole and the remaining two are run on the respective insulators of a seven foot cross arm with a separation of six feet between the pins. The wires are not transposed, and a metallic telephone circuit is carried on brackets at a distance of 42 inches below the cross arm.



THE 40,000-VOLT TRANSFORMERS.

The insulators are of a special type of triple petticoat glass, having two corrugations around the top below the groove designed to carry the line wire. This arrangement not only has the advantage of increasing the surface of the glass between the wire and pin, but it also protects a portion of the surface from extreme moisture during rain storms. The approximate dimensions of the insulator are 6½ inches across the base by 6 inches high, and the insulator is supported by a specially long locust pin made proof against moisture by being boiled in paraffine. Great care was taken to fill the pores of the wood thoroughly, to effect which the pins were kept in the tank in which they had been boiled until they had become thoroughly cooled, after which the surplus wax was removed and the surface of the pin was made smooth by dipping it again in very hot paraffine wax. These pins, being extra long, supported the insulator clear of the cross arm by five inches and the pin used at the top of the pole is two inches longer still, making the separation between the top insulator and the pole to be seven inches.

It appears obvious that an insulator of this design will offer a high resistance to a discharge over its surface, but should it be assumed that it could reach the lower edge of the outside petticoat, there would be little inducement for it to go further as the pin is at all times a good insulator and its surface is of such a nature that a film of moisture will not collect over it. On several occasions insulators have been shattered by marksmen, but it has been the experience that if trouble developed owing to the grounding of the wire on the pin or cross arm, it would promptly rectify itself by the burning off of the cross arm, leaving the wire without support at that pole.

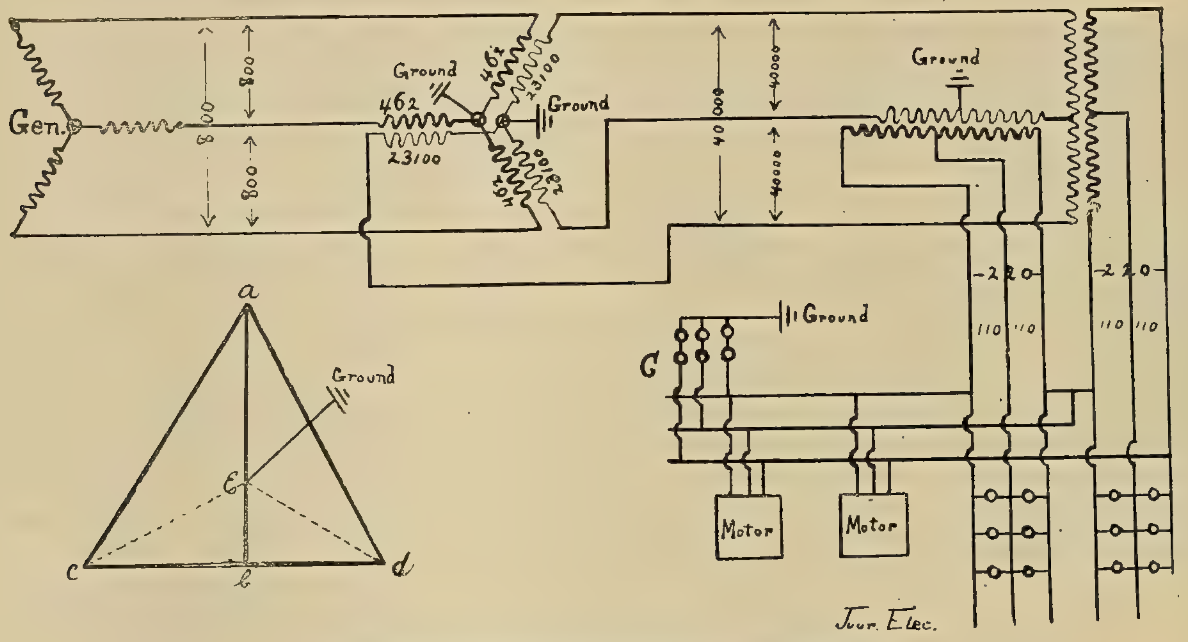
It will be interesting to note that at each pole along the line one can hear crackling from static discharges at all times, and during certain atmospheric conditions, the insulators are dimly luminous with pale phosphorescence. The line itself, however, is non-luminous at all times except for the brush discharges which sometimes exist from points of the line, such as from the tips of the tie wires.

The lightning arresters, as before stated, are of the Wurts type. About twenty-five arresters being kept between the line and the ground. Six choke coils are used, and these are placed edgewise on top of the arrester racks, and as the latter are designed to be as compact as possible, they measure over all but 2 feet, by 3½ feet, by 7 feet high. One of these banks of lightning arresters and choke coils are connected in each line wire as shown in the illustration on page 169.

To be more explicit, the connections of the lightning arresters are arranged as follows: Six choke coils are coupled in series and cut into the line after leaving the transformers. For convenience, we will designate the choke coils by numerals consecutively, coil number 1 being at the left and being connected direct to the line. On the line side of each coil numbered 1 and 2, three Wurts arresters, each containing seven non-arcing cylinders, with about one-twentieth inch gap, are tapped off in series, there being thus two series of three arresters each, for the first two coils. The free ends of the two series of arresters from coils numbered 1 and 2 are closed together, the connection thus formed being termed "point *a*." Similarly the two series of arresters from coils numbered 3 and 4 are connected at point *b*, as are also the two series of arresters of coils 5 and 6 at point *c*. From points *a* and *b* are then carried a single series of five arresters, the ends of these series being joined at the point *d*, while from point *c* is run a single series of eight arresters which are connected to (at point *e*) the terminal of a single series of three arresters between *d* and *e*. Eleven choke coils therefore, intervene between point *e* and either of the six choke coils referred to, while from point *e* is continued a single series of fourteen arresters running to ground. About twenty-five arresters intervene between any choke coil and ground while a minimum of six arresters are across a coil.

Two further features of interest, also shown in the engraving last referred to, are found in the fuses inserted in the high tension wires, and in the high tension switches used. Each of these three fuses, consists of a single No. 30 B. & S. bare copper wire, thirty-six inches in length, over which an asbestos tube is drawn. The fact that three such thread-like wires will carry a load of over seven hundred horse power, is as incredible to the layman as it is evident to the electrical engineer who fully realize the significance of transmission at a potential of 40,000 volts.

The high tension switches, illustrated on page 170, are inserted on each of the three line wires. They are rigidly connected together so as to be operated by a common switch bar as shown, and each give to a six-foot break, the separation between the switches being five feet.



OUTLINE CIRCUITS OF PROVO-MERCUR TRANSMISSION

The sub-station now in operation is installed in the Golden Gate mill, at Mercur, which is believed to be one of the largest, if not the largest, cyanide mill in the world. Its electrical equipment, aside from the induction motors used for mining and milling purposes, and as about to be described, consists of three, 300-kw. lowering transformers by means of which the 40,000-volt three phase line current is reduced to 220-volt, two phase current, used for lighting and for operating Westinghouse two phase type "C" induction motors. The plan of connections for the step-down transformers is shown in the sketch on this page, which is a comprehensive outline drawing of the electrical connections of the entire quipment from the generator to the ultimate motors and incandescent lights operated by the system.

These lowering transformers are the same in general design as the raising transfomers in the power house at Provo Canyon, and differ therefrom only in capacity and voltage. It will be noticed too, that, as is the case in the generating station, an extra transformer is installed for emergency use and its connections are so arranged that it can be substituted for either of the other lowering transformers with celerity.

The transforming of three phase current to two phase current and vice versa, by two transformers, is generally understood and will therefore not be taken up.* As previously stated, the neutral point of the three phase system in both the generator and the high tension side of the raising transformers are grounded, and the practice of grounding is carried out even in the low tension distribution circuits in the manner to be shown.

The neutral point of a three phase circuit in a three phase-two phase transformer may be determined graphically by erecting the perpendicular *b a* from the center of the side *c d* of the equilateral triangle shown in the corner of the above plan of circuit connections, and upon this perpendicular *b a*, locate the center of the triangle as shown at the point *e*. Let the line *a b* represent the 100 per cent. side of a three phase-two phase transformer, when the line *c c* will represent the 86 per cent transformers, and the point *e* will be one-third of the length of the line *b a*, measured from *b*. It is at this point that the tap for the ground is brought out, and it is located in the three phase-two phase transformers at one-third of the turns of the 86 per cent. transformer, from the side connected to the center of the 100 per cent. transformer.

The 220-volt secondary is also grounded through incandescent lamps as shown at *C*, where two 110-volt lamps are connected in series between either of the three wires of the two phase distribution, and the ground. Moreover, a tap is brought out from the center of each of the single phases comprising the two phase system and this tap constitutes the neutral wire of the Edison three wire system which is used at Mercur for incandescent distribution service. Lighting service is taken from both transformers, great care being exercised to keep the entire system balanced, not only as an Edison three wire system, but also to keep each of the two phases balanced with the other. The thoroughness with which the various portions of the high tension three phase system is grounded, as well as the effectual grounding of the 220-volt system, leads to the belief that no danger from shock is presented.

---

*See "Alternate Current Workings" by Donald H. Fry; Journal of Electricity, Vol. V. No. 7, April, 1898.

A further feature that will excite surprise is the fact that current is carried from the lowering transformers to the center of distribution in the Golden Gate mill and hoist house by a three-conductor concentric cable, each of the three conductors having a sectional area of 1,000,000 circular mils. The length of this cable leading into the mill is 220 feet and from its terminal is tapped off leads for six induction motors, consisting of one 150 hp. operating rolls, etc.; one 50 hp. motor operating the roasters; one 30 hp. motor operating pumps; two 15 hp. motors operating blowers, and one 10 hp. motor in the machine shop. The length of cable leading into the hoist house is about 60 feet, and from its terminal is tapped off leads for three motors consisting of one 150 hp. and one 75 hp. motors operating hoists and one 100 hp. motor operating an air compressor.

Two other motors, each of 50 hp. operating rock crushers, are run on independent leads from the transformers, and these complete the plant.

TRANSFORMER REGULATION.

By A. R. EVEREST.

REGULATION drop, in a transformer, is the drop in voltage at the secondary terminals of the transformer itself, the primary voltage remaining constant.

Apparently the easiest way to determine the regulation of a transformer would be by direct measurement of the voltage at the secondary terminals; first, when the transformer is carrying no load, and secondly, when the tansformer is carrying full load, the difference between the two being the regulation drop, provided the primary voltage is kept constant. In practice, however, this test is attended with a number of difficulties,—so great, in fact, as to render the test perhaps the most difficult and unsatisfactory of all transformer tests. Even when the voltage on the primary side is observed by an independent voltmeter (and step-down transformer) it may frequently happen that the temperature co-efficients of the two voltmeters are not alike, producing discrepancies in the readings, which, in themselves small, produce a large percentage error in the capacity to be finally determined.

Absolutely steady readings are also desirable for the success of this test, a condition which is very seldom attained. The pulsations of a slow-speed engine reflected on the voltmeter needle are often sufficient to make the test absolutely worthless. There are, as well, several other minor factors which tend to disturb this test, most of which can be met independently, as by exchanging voltmeters between readings, by taking large numbers of readings at each point and averaging results, and so on; but experience continually shows that with the greatest care the results obtained by this method cannot always be relied upon.

Perhaps the hardest point of all in connection with the regulation test, as commonly made, is the difficulty of persuading the station electrician who makes his own tests that his results (often absurd) are open to question. But since the losses creating the regulation drop in a transformer can be independently measured, the calculation of the regulation from these observed losses becomes a simple matter.

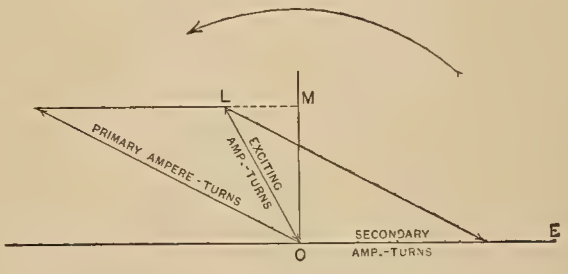


Fig. 1

The "regulation drop" in a transformer is caused by two losses. First, the energy loss, or *C. R.* drop in the transformer windings; secondly, the reactive drop, or "inductance" of the transformer. In certain special cases there must also be taken into consideration the effect of the magnetizing current in the primary, since when the latter is relatively large it produces a phase displacement between the primary and secondary currents and has the same effect on regulation as an increase in the reactive drop.

When this phase displacement is so small as to be insignificant, the calculation of the drop of the transformer is reduced to the resolution of a right-angle triangle.

Draw for the base line the total energy drop, including that in the transformer and in the external circuit. Perpendicular to this, lay off a line representing the reactive drop in the transformer, (in which it is assumed that the external load is non-inductive). The hypothenuse joining these two sides of the triangle now represents the primary applied voltage. We may call this 100 per cent.

If the reactive drop is, say 3 per cent., the horizontal becomes the square root of 100^2 minus 3^2, or roughly 99.2 per cent. If the known *C. R.* drop in the transformer amounts to 2.2 per cent we have left 97 per cent voltage (=99.2 per cent—2.2 per cent) at the secondary terminals, as compared with the primary input, or, in other words, there is 3 per cent regulation drop in the transformer. In many cases, however, especially when testing an unknown transformer, it is necessary to take into account the effect of the magnetizing current. The calculation is then not quite so simple, but by means of the method about to be shown, the determination can be made with the greatest accuracy. This method has the advantage of appealing directly to the eye by means of the well known "transformer diagram".

Figure 1 shows the relative directions of secondary current, primary current, the resultant magnetizing force and flux. *O L* is the primary exciting current at no load. It consists of two components, *O M* the true magnetizing component in phase with the flux *O M*; and *M L* at right angles to this, which is the energy component representing the energy expended in core loss.

When the the secondary circuit is closed, the primary current will adjust itself in magnitude and direction so as to maintain the vector *O L* as resultant of primary and secondary magnetizing forces.

The magnetic flux *O M* generates in the tranformer windings a voltage *O E*, 90 degrees behind the flux in phase. This is the active voltage of the secondary circuit, and also appears as the counter electromotive force in the primary circuit, where it is shown as *O I* (Figure 2.)

It is here assumed that the secondary circuit is non-inductive, hence the secondary current is in phase with the induced electromotive force *O E*. (For simplicity it is also assumed that the transformer has a 1:1 ratio). The voltage impressed on the primary to maintain the secondary current must be the resultant of three components (Figure 2.) *I O*, opposing counter electro motive force 90 degrees ahead of flux *O M*. *D I*, overcoming primary C. R. drop in phase with primary current. *R D*, opposing reactive drop, and 90 degrees ahead of primary current. The resultant of these is *O. R.* which is primary impressed voltage.

It will be noted that this primary voltage *O R* is really the resultant of *two* values, *R I* the primary impedance drop, *I O* the secondary induced electromotive-force. If we can calculate these, and know the secondary C. R., we have the regulation at once.

It will be observed that any increase in magnetizing component increases the lag between primary current *O P* and counter *O I*. Since the base line *I D* of primary impedance triangle (the C. R. drop) must always be parallel to *O P*, (the primary current) it follows that an increase in magnetizing component will swing the primary impedance vector *I R* more into phase with the secondary induced volts *I O*, increasing the value of the primary impressed voltage *O R* for any given secondary voltage.

If the diagram is plotted on squared paper with sufficient accuracy, the regulation can be obtained at once from Figure 2, since when *O R* is the primary impressed voltage, *O I* is to the same scale, the secondary induced voltage, and may be expressed in per cent. of the former. Deducting the secondary C. R. drop in per cent, we have the percentage of primary voltage appearing at secondary terminals. But for greater accuracy it is preferable to calculate the side of the diagram.

Let in Figure 3 the vectors *I D* and *D R* be replaced by *I J* and *J R*, the vector of primary impedance *I R* remaining unchanged.

From the known values of primary impedance, C R and reactance, the angle *a* of the impedance triangle is known. The corresponding angle *J I R*=*b* of the new triangle is equal to *a* reduced by the small angle *J I D*. But this latter angle is the angle of lag between the primary current and the counter and is readily found from the known values of exciting and full load current. A tabulation of the lag angle for values of exciting current from 5 per cent to 20 per cent is given further on.

Having found the new angle *b* and knowing the value of primary impedance, the new vector *J R* (which we may call equivalent reactive drop) is found as the sine of the angle *b* and the vector *I J* (or equivalent primary C R) which is the cosine of the same angle.

Having expressed all the values in per cent of primary voltage for convenience, we now resolve the right angle triangle *O R J* taking *O R*=100 per cent *R J*=the equivalent reactive drop in per cent—and obtain *O J* which is secondary terminal volts in per cent, plus the secondary C R per cent plus the primary equivalent C R per cent. Knowing the last two values, we have the per cent. of primary voltage appearing at secondary terminals, and therefore the *regulation* of the transformer.

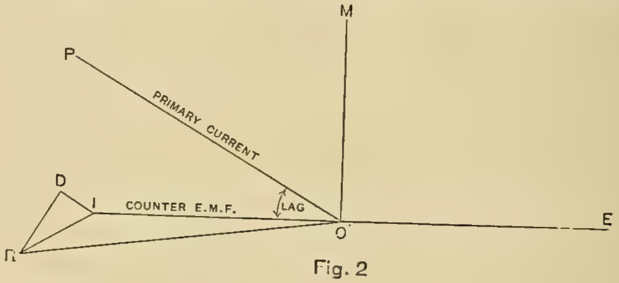


Fig. 2

As an illustration, the method will be applied to the determination of regulation drop at full load of a transformer on which the following measurements are known.

The measurements of copper loss and impedance drop are made by means of a wattmeter, the secondary of the transformer being short circuited as described in Dr. Bedell's paper on transformer regulation published in "The Electrical World."

Capacity of transformers, 2500 watts.
Ratio of transformation, 10:1.
Primary voltage, 1000; frequency, 125 cycles.
Copper loss, (C^2 R), 50 watts.
C. R. drop, 2 per cent.
Impedance drop, 54 volts = 5.4 per cent.
Iron loss, 60 watts.
Exciting current, (no load current in primary at 1000 volts), .125 amp.

TABLE OF PRIMARY CURRENT LAG.

Per cent. Exciting Current	Angle of Lag
5 per cent.	2.0 deg.
8 "	3.5 "
10 "	4.5 "
12 "	5.0 "
14 "	6.0 "
16 "	6.5 "
18 "	7.5 "
20 "	8.0 "

This table is not correct for frequencies below 50 cycles.

The lag angle of primary current behind the counter line is determined from the relative values of primary exciting current, the primary full lead current. For convenience, the lag angles are tabulated below for values of exciting current from 5 per cent to 20 per cent on the assumption that the magnetizing component is 80 per cent of the exciting current. (This is sufficiently accurate for all ordinary transformers on frequencies of 50 cycles and above. The value increases, tending towards 100 per cent with the large exciting currents accompanying very low frequencies).

In the case under consideration, we have exciting current 5 per cent, lag angle, 2 degrees.

The total independance drop is 5.4 per cent., the C R drop 2 per cent., and reactive drop $\sqrt{5.4^2-2^2}=5$ per cent.

The *primary* impedance drop is resultant of reactive drop and primary C. R. drop, which we may take as one-half of total C. R. drop. It is therefore $\sqrt{5^2+1^2}=5.1$ per cent.

In figure 2, we then have $I\ R=5.1$ per cent.

$I\ D=1$ per cent.

$D\ R=5$ per cent.

To find the angle $R\ I\ D$ we find what angle has its sine $(R\ \ D)=\frac{5}{5.1}=.981$. The angle is 79 degrees (See angle a figure 3). Deducting from this the current lag angle we have for the angle b 77 degrees. $J\ R$ is the sine of this new angle and is $.974\times 5.1=4.96$ per cent. Similarly $J\ I$ is the cosine of 77 degrees and is in value $.225\times 5.1=1.15$ per cent.

To determine the regulation we now resolve the right triangle $R\ O\ J$.

$R\ O=100$ per cent.

$R\ J=4.96$ per cent.

$J\ O=\sqrt{100^2-496^2}=99.87$ per cent.

Deducting $J\ I$—1.15 per cent, we have 98.22 per cent as secondary induced voltage $(I\ O)$ and deducting again secondary C. R. drop 1 per cent we have 97.72 per cent of primary applied voltage appearing at the secondary terminals or a regulation drop of 2.28 per cent.

It is of interest to note here that figuring the regulation of this transformer by the simpler method first described, entirely ignoring the effect of exciting current, the result gives 2.13 per cent regulation drop, a difference of 0.15 per cent due to 5 per cent exciting current. With a larger reactive drop in the transformer, other losses being equal, the difference between results obtained by the two methods would be somewhat geater.

Calculated by Dr. Bedell's method before referred to, the regulation drop obtained is 2.44 per cent,—slightly higher than that by the method above. This is due to the fact that Dr. Bedell's method assumes that the magnetizing current is equal to the exciting current which is not the case, and also in a slight degree to some other minor approximations adopted in the construction of his diagram.

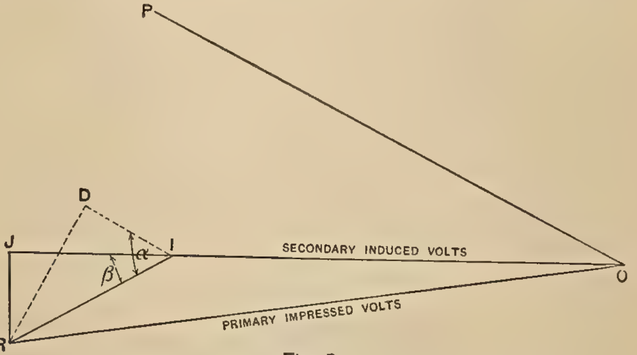


Fig. 3

The percentage of iron loss and exciting current taken in the above illustration are higher than would be found in good modern transformers of any but the smallest sizes but they have been purposely taken here to illustrate the point under discussion. For the same reason the diagrams are greatly exaggerated. In actual practice the primary current line $O\ P$ is very nearly parallel with the line $O\ I$.

Fraternal

THE ANNUAL MEETING OF THE TRANSMISSION ASSOCIATION.

The annual meeting of the Pacific Coast Electric Transmission Association will be held at San Francisco on Tuesday, the 21st day of June, 1898. The session will be opened at the Cliff House at 2 o'clock in the afternoon.

After the enrollment of new members, papers will be read by E. S. Cobb, M. E., on "Electrically Driven Centrifugal Pumps;" R. S. Masson, Electrical Engineer of the Pacific Coast District of Westinghouse Electric Mfg. Co., on "Electric Motors for Pumps;" F. F. Barbour, Manager, Power and Mining Department of General Electric Company, Pacific Coast District, on "Distribution in small units from High Potential Circuits," and Leon W. Bly of Telluride, Colo., on "Some Experience in Extreme High Potential Work."

There will also be presented papers by John Martin, Pacific Coast Agent, Stanley Electric Manufacturing Company, and R. M. Jones, manager of the Big Cottonwood Power Company of Salt Lake City.

A supper, to be provided by the Association, will be served at 6 p. m., after which the evening will be devoted to the reading and discussion of papers.

The coming meeting promises to be a very interesting and instructive one, and it is hoped that all of the members of the Association will be represented so as to avail themselves of the opportunity afforded to gain practical information from those who have had experience with electric transmissions under working conditions, and to form acquaintances which will prove pleasant and profitable. As stated, the supper will be provided by the Association, and each member entitled to two representatives.

Mining

ELECTRICITY IN MINING.—II.

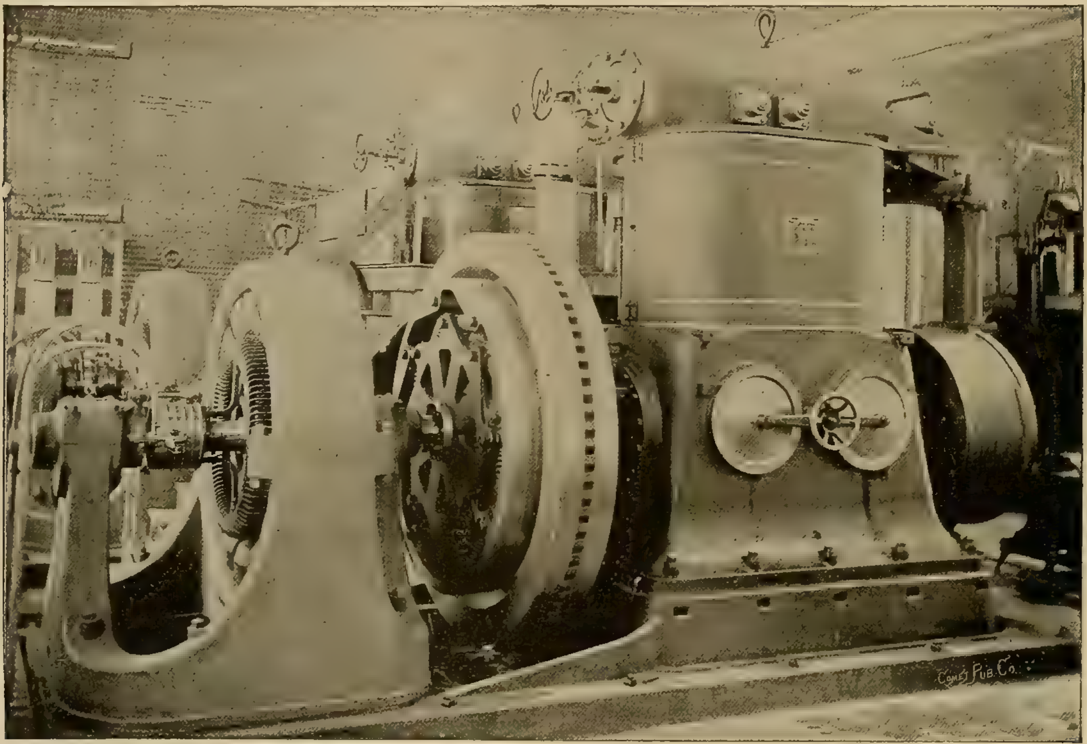
THE application of electricity to the art of mining has been developed largely within the past five years. In 1893, Prof. John P. Barrett, in his book, "Electricity at the World's Columbian Exposition," made the following statement: "As applied to mining, electricity is comparatively new, and its advent is in consonance with the commercial success of the alternating current for lighting and power work. Heretofore the difficulties have related to cost alone."

"The commercial success of the alternating current" has been largely due to the fact that the experts of one of the largest of electrical manufacturing companies developed that form of electrical power in the face o considerable opposition, both from men of science and from legislative assemblies. The manufacturers are reaping their reward, however, in the present state of electrical construction.

Thanks to the efforts of such enthusiasts, the question of cost has ceased to discount the use of electric apparatus. Where a source of water power is available, even though at a considerable distance, the modern methods of long distance transmission at high potential make the operative expense of an electrically equipped mine ridiculously small when compared with the figure for any other form of power. Even where the mine is operated by electrical machinery which is itself driven by steam power, the convenience and safety of electric transmission make it by far the most economical method—with present efficiencies—of all that have been proposed.

The long distance system depends for its success upon the well known property of alternating current which makes it possible to transform it, by means of suitable apparatus, from a small current at a very high voltage to a larger current at any desired lower voltage, the amounts of current in the two cases being inversely as the voltages at which they are carried. As the waste of energy in transmission varies with the square of the current, it will be seen that the loss in transmission over a long distance line will be very small because of the small amount of current carried. At Niagara Falls, where the power of the cataract is developed by 40,000 horse power of Westinghouse generators, the current is distributed in this way over a radius of 30 miles, and is sold at Buffalo, the extreme point of distribution, for sixty-four hundredths of one cent per kilowatt. This is equivalent to less than one-half of one cent per horse power per hour. It is safe to assert that nothing approaching this efficiency has ever been attained in mining practice with any other kind of power.

The advertising efforts of the larger of the electric companies have been for the past few years directed toward extending the range of application of their pro-



A CORNER IN THE WESTINGHOUSE STATION.

ducts. In the arts of papermaking,* printing, tanning, in packing houses,** lumber mills, textile plants, and in mining, the advantages of electric power have been more or less thoroughly exploited. It is the object of this article to inquire into these advantages and to ascertain the degree to which the results obtained in practice will bear out the claims of the advocates of electric power in mining.

Cheapness is not the only requisite of success. A tallow candle on a miner's hat is cheaper than a safety lamp, at least in first cost; subsequent events may disprove the contention.

Power as used in mining, may be classed under the following heads, which will be considered separately:

1. Motive power, tramways, hoists, etc.
2. Lighting.
3. Auxiliary power, ventilating fans, pumps, etc.
4. Operative power, drills, picks, stamps, crushers, compressors, and other machinery.

Steam, water, and compressed air are the principal other forms of power employed. The items of expense in a steam plant are as follows: boiler, engines, (condensers, etc.), piping to points of distribution, with costly valves and auxiliary apparatus. The expense of operation comprises coal, water, oil, and expert attendance. Where compressed air is used, there must be added compressors storage tanks, and additional piping and operating expense. The hydraulic system is available in certain cases for special purposes involving the expense of a dam or of a reservoir and pump, unless nature has provided their equivalent. Complicated systems of piping and machinery are required. Aside from the item of cost, there are objections to all of these systems, because of various defects of adaptability, safety and the like.

Electric power is clean, safe, convenient, and in mining districts, as explained above, usually cheap. It produces no refuse, no troublesome side products; it is easily transmitted, and occupies modestly only a very small amount of space in its travels through the recesses of the mine. The advantages here enumerated may be studied from a practical standpoint in the many large mining installations throughout the country, designed and installed by the principal electric companies.

1 ELECTRIC HOISTS AND TRAMWAYS.

The requisites of a successful mine hoist vary according to the special kind of service. For some purposes, the mechanism must be well protected from dust; for others, it should be thoroughly ventilated; in almost every service, the elevator must be capable of reversal without changing or adjusting the prime mover. The latter should require little attention, and should not be liable to derangement. Constant speed is often desirable; constant torque is sometimes required.

These essentials are met satisfactorily by the modern type of dust proof motor. This machine, developed by the Westinghouse company, is an offshoot of the standard type of multipolar motor, which has become famous. It is designed to hang in almost any position, is securely encased in a cylindrical frame, and is absolutely spark proof and dust proof. As an example of the freedom of these motors from sparking, it may be mentioned that one of them was supplied by the Westinghouse company for the ammunition hoist of the United States battle ship "Indiana," and was naturally subjected to very severe service, in which, however, it has given entire satisfaction. The brushes require no attention, and the direction of rotation is reversed without the least regard for the ordinary motor sensibilities. As applied to mining hoists, this type of machine has attained unquestioned success. It is made in sizes of from 10 to 200 horse power.

Where the presence of explosive gases makes the use of direct current unadvisable, a polyphase system, preferably of low frequency may be introduced. Polyphase machines are made of the inductor type, i. e., without brushes or sliding contacts. Polyphase transmission may be direct, that is, generated near the points of distribution at the voltage desired or indirect, in which case transformers are used as previously descibed. A noteworthy example of the former case is at the immense factory of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Penn. A view of one corner of the power house is shown in page 176. All the machinery in this great establishment, comprising upward of 1300 machine tools, is driven by electricity supplied to Tesla polyphase motors, the current being two-phase, with a frequency of 25 cycles per second. The potential used is 200 volts, and this being approximately the generator voltage, is supplied without the interposition of transformers.

In using the polyphase system it should be noted that if the frequency selected be suitable, the mines can be lighted from the same circuits that are used to supply power. A frequency of 25 cycles per second permits incandescent lighting that is entirely satisfactory for mine work, but it is too low for arc lighting. A line of polyphase motors is built by the electrical companies for a frequency of 60, and this is adapted to both incandescent and arc lighting. The lower frequency possesses the advantage of reducing the speed of the motors.*

The electric locomotive has passed the experimental stage and is an assured success, as has been demonstrated in scores of instances. For mining work, it may be said that the electric locomotive is the only locomotive. No smoke, no dust, no moving cable, no danger or inconvenience of any kind accompanies its use. It is compact in form and noiseless in operation. For hauling in mines electricity is fast superceding steam and mule power. In well ventilated mines there is no danger from the ignition of the gas by sparks from the electric machinery, and the electric locomotive does not vitiate the air. The small amount of apparatus necessary for the installation of the electric plant is in its favor, as a small copper wire takes the place of the large amount of piping and the air storage tanks for pneumatic locomotives. The weight of an electric locomotive is less than of a compressed air or a steam locomotive adapted to the same work, as the apparatus for generating or storing the power in a central station instead of on the machine, as is the case with steam and pneumatic locomotives. The capacity for hauling on grades is greater, as the full power of the central station is available, up to the full capacity of the motors, which are thus enabled to perform temporarily an abnormal amount of work when suddenly called upon for such service.

---

*See paper by Mr. Chas. F. Scott, on "Electricity in Paper Making," read before the American Paper and Pulp Association, February 16, 1898.

**See "Electricity in Packing Houses," "The Western Electrician," May 28, 1898.

*Some technical consideration governing the design of mining motors are set forth in an article by Prof. F. C. Caldwell in "Mines and Minerals" of May, 1898, entitled "The Design of Mining Motors."

The capacity of electric locomotives ranges from 50 to 200 horse power, and the draw bar pull from 3000 to 10,000 pounds or more, according to the weight. The draw bar pull may be increased by adding cast iron to get adhesion to the rails. The locomotives are constructed in the same substantial manner as steam locomotives. The gears are of cast steel or malleable iron, machine cut, and run in oil tight cases.

*The smaller sizes may be adapted for wooden rails, but where the wooden rails have not an iron edge, the wheels are made with a special tread and flange, and therefore a description of the rail on which a locomotive is to run should always accompany an inquiry.

The Westinghouse-Baldwin locomotive frame consists of heavy cast iron side and end pieces securely bolted together and kept square by machined joints and shoulders accurately fitted. These frame pieces are planed top and bottom and on the ends, to insure perfect accuracy in fitting up, and inter-changability of parts. The pedestal caps are forgings made to template and accurately fitted so as to relieve the frame from breaking strains in case of severe shocks. The frame is placed outside the wheels, thus allowing all possible space between wheel hubs to admit the greatest practicable width of motor. This feature is of much importance in obtaining the maximum power on narrow guages. Furthermore, this construction permits of ready accessibility to the journal boxes and protects all moving parts in case of derailment. Heavy planking with hinged doors is laid on top of frames, thoroughly protecting all electrical parts while permitting access to the same for inspection. End bumpers and coupling hooks are provided in conformity with the purchaser's requirements. The operating platform is placed at one end and is compactly and conveniently arranged so that the motorman has all levers within reach without leaving his seat.

The locomotive is driven by two spring supported motors, one geared to each axle by single reduction gearing running in oil lubrication in tight cases. These motors are designed especially for mining service and are of the four pole, steel clad, enclosed railway type. The armature is iron clad, the coils being held in slots below the surface and secured by wooden wedges, as in the most approved railway practice.

The current controller is of the latest rheostatic type, with magnetic blow out to prevent arcing at the contacts. It is provided with six speed changes and is operated with handles for starting and reversing.

The trolley pole is especially designed for this service. It is reversible and can be placed in a socket on either side of the frame. It automatically adjusts itself to varying heights of trolley wire, and is thoroughly insulated to prevent shocks to the operator when being handled. The current connections are made by insulated cable.

The locomotive is provided with all necessary minor electrical fittings, such as fuses, lightning arrester, main switch, and two electric headlights.

All sizes of this locomotive are designed to run at a standard speed of eight miles per hour while developing their full tractive effort. With light trains requiring less than full power, the speed of the locomotive may be increased. When starting, the train is brought up to speed gradually by means of the controller.

The accompanying table gives the standard sizes of of Westinghouse-Baldwin mining locomotives with their performance, weight, and minimum dimensions. The draw bar pull has been figured at full load and standard speed for the locomotives hauling trains on a straight level track, and also on the limiting grades, found in ordinary mining practice; the assumed adhesion of the locomotive being that with a fairly good condition of the track and rail.

Curves offer considerable additional resistance to the movement of the locomotive and cars, and must be taken into account if of short radius, especially when they occur on grades. With the track in fair condition the curve resistance may be taken at one pound per ton weight of trains per degree of curvature.

The number of tons weight which a locomotive will haul at standard speed on straight track may be calculated from the table, when the grade and frictional resistance of the cars is known. The frictional resistance will vary greatly with the kind of cars, the conditions of journal lubrication and the condition of the track.

For the average mining locomotive, the friction may be taken at thirty pounds per net ton weight of the loaded cars, but it may frequently amount to forty pounds per ton or more, where conditions are unfavorable. To find, therefore, the number of tons (2000 lbs.) of train which can be hauled by a given locomotive, take from the table the number of pounds of draw bar pull that will be exerted by the locomotive on the limiting grade in the mine, and divide that figure by the train resistance in pounds per ton on the grade; the quotient will be the weight of train hauled. The train resistance per ton is found by multiplying the per cent. of

---

*See pamphlet on "Electric Locomotives," by David Leonard Barnes.

grade by 20 lbs. and adding 40 lbs. friction to the result.

All these locomotives have parallel rods, which prevent loss of power and time, due to slipping of individual axles. This is an important feature where there is fine coal dust or moisture. Each locomotive is provided with two sand boxes, front and back, both of which can be operated from either end. These sand boxes can be provided with electric heaters, if desired, to keep the sand dry. The protection for the head of the motorman is hinged to swing so that he can stand erect in parts of the mines where the head room is sufficient. Suitable brakes are provided, which can be operated from either end, and are powerful enough to utilize the entire adhesion for braking force. The gears are of the best wearing material, accurately cut. The wheels may have chilled treads or steel tires shrunk on, while the crank pins and parallel rods are of open hearth steel, the rods having bronze bushings. One of the largest of this class of mining locomotives which has been in constant daily use for months, has a capacity of 200 horse power at six miles per hour with a track guage of three feet six inches. These requirements make it necessary to raise the motors above the wheels, and to use intermediate gearing. The Westinghouse Company furnishes photographs of the uncovered machine, showing how this is accomplished. This 200 horse power mining locomotive is covered at the points requiring protection from the rain, hence all parts are accessible and can be watched by the engineer while in motion.

Class	Total H.P.	Speed M.P.H.	Full Load Draw Bar Pull in Pounds					Minimum Track Gauge	Wheel Base	Diam. of Wheel	Width	Length	Height.	Wght Lbs
			Level	1 per cent grade	2 per cent grade	3 per cent grade	4 per cent grade							
$4\frac{2}{\ }c$	20	8	900	840	780	720	660	24 in.	44 in.	24 in.	41 in.	10 ft. 4 in.	33 in.	7000
$4\frac{2}{10}c$	20	8	900	840	780	720	660	30 in.	44 in.	28 in.	47½ in.	10 ft. 4 in.	33 in.	7000
$4\frac{2}{15}c$	30	8	1250	1170	1090	1010	930	30 in.	44 in.	28 in.	47½ in.	10 ft. 4 in.	33 in.	8500
$4\frac{2}{25}c$	50	8	2100	1980	1860	1740	1620	30 in.	44 in.	30 in.	48 in.	10 ft. 4 in.	33 in.	12000
$4\frac{2}{35}c$	70	8	2900	2730	2560	2390	2120	30 in.	48 in.	30 in.	53 in.	11 ft. 6 in.	34 in.	17000
$4\frac{2}{50}c$	100	8	4300	4060	3820	3580	3340	36 in.	48 in.	30 in.	53 in.	12 ft. 0 in.	36 in.	24000
$4\frac{2}{75}c$	150	8	6500	6160	5820	5480	5140	56½ in.	60 in.	36 in.	74 in.	13 ft. 6 in.	42 in.	34000

PERFORMANCE AND LIMITING DIMENSIONS OF MINING LOCOMOTIVES.

The size of locomotive required for any given case may be calculated, but is preferably determined by making a number of tests with a dynamometer to ascertain the draw bar pull. It is of the greatest importance to have sufficient weight on the drivers.

Tests made by Messrs. Buck and Belsey, students at Sibley College, Cornell University, gave the following instructive results:—

The ratio of the dynamometric horse power to the electrical horse power at the motor terminals was from 42 per cent. to 65 per cent. at a speed of from four to six miles per hour, the maximum draw bar pull recorded being 5,700 lbs. The locomotive was a 10-ton, 80 hp. machine, with a single reduction motor, the axis of the armature lying in the direction of the track; both pairs of wheels were geared to it by bevel gears. A shop test of this locomotive, under which 86.7 ehp. was delivered to the machine, and a speed of 8.56 miles per hour obtained, gave as the total losses 21 hp., or 24 per cent., of which the gear loss was 5.5 hp. or 6.4 per cent. The rolling friction was 5.7 hp., or 6.6 per cent, and the electrical loss 9.7 hp., or 11.2 per cent. The measured draw bar pull was 2,700 lbs. The Baldwin-Westinghouse electric lomocotive, previously described, greatly surpasses in efficiency any such results as the above.

The rapid development of the electric locomotive is explained by the fact that the greatest companies in their respective fields of electricity and locomotive construction, the Westinghouse Electric and Manufacturing Company and the Baldwin Locomotive Works—joined forces in this direction and worked out jointly the details of these machines. The Westinghouse-Baldwin is the product of that union, and is a successful locomotive of to-day. Mr. R. G. Vance, Superintendent of the Stevens Coal Co., Acme, W. Va., writes, "It (a Westinghouse-Baldwin mining locomotive) works like a charm * * * It will do from 25 to 50 per cent. more work than the specifications call for."

(Continued in Next Number.)

Personal

Dr. F. A. C. Perrine, electrical engineer for the Standard Electrical Company of California, has left for a business trip in the East and will probably be absent for two months.

Mr. Robert McF. Doble has resigned the secretaryship of the Blue Lakes Water Company and will hereafter devote himself to the duties of his position of president and manager of the Abner Doble Company.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity, Gas and Power.

OFFICIAL ORGAN OF THE PACIFIC COAST
ELECTRIC TRANSMISSION ASSOCIATION.

SUBSCRIPTION PAYABLE IN ADVANCE. TERMS—DOMESTIC, ONE DOLLAR PER YEAR; FOREIGN, TWO DOLLARS PER YEAR.
RATES FOR ADVERTISING ON APPLICATION.

The trade supplied by the San Francisco News Company.

EDITED AND PUBLISHED BY GEO. P. LOW.

Business Office, 22 CLAY STREET
Telephone, Steiner 623.

Address all communications to
Editorial Rooms, 427 TENTH AVE

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME V. JUNE, 1898. NUMBER 9

EDITORIAL.

THE P. C. E. T. CONVENTION.

With this month comes the second annual meeting of the Pacific Coast Electric Transmission Association, to be held at the Cliff House, San Francisco, beginning Tuesday, June 21st, as announced on another page in this issue. From the list of papers to be presented and from the number of letters that have been received from members expressing an intention to be present, no doubt is felt but that the coming convention will be one of the most successful and profitable gatherings of technical men ever assembled on the Pacific Coast.

The interest which is being taken in the affairs of the Transmission Association is indicative of the growing importance of the industry it represents in the Far West. A chapter in the history of the development of this industry is told in the editorial following this and ere the month closes, the transactions of the Transmission Association will have exceeded the latest and best advances in the electric transmission of energy.

It is well that the Constitution of the Association, as ultimately adopted, pursues a liberal course in regard to membership for, while adhering vigorously to the qualifications for active members, it avails itself of the wisdom and experience of its hosts of allied interests by permiting their enrollment as Associate members. The fruits of this sound policy are being evidenced in the rapid increase in the list of associate members, and it is urged that applications for associate membership be made by all who are interested in, or have dealings of any nature with electric transmission enterprises. No feature of the industry is too small for investigation and scruntiny and thorough specialization is the keynote of highest attainment in operation efficiency.

A milestone marking the progress of the electric transmission industry was turned in the permanent organization of the Pacific Coast Electric Transmission Association by the election of its first board of officers, and as a fitting observance of the event the Journal of Electricity presents, as a frontispiece to the volume now closing, the portraits of its first officers.

Of these, the President of the Association, Mr. C. P. Gilbert, is a graduate of the University of Michigan as an electrical engineer in the class of 1870, whence he served as United States assistant engineer on various government works until 1888. He then took charge of the business of the Edison Illuminating Company, of Detroit, Mich., as secretary and manager, during which time he was elected Vice President of the Association of Edison Illuminating Companies, afterwards serving for several years as chairman of its executive committee. Since July, 1896, Mr. Gilbert has been General Manager of the Sacramento Electric, Gas and Railway Company, of Sacramento, Cal.

Mr. H. H. Sinclair, Vice President of the Association, has been prominently before the electrical fraternity from early in the '90s, when he pioneered three phase systems in the transmission of the Redlands Light and Power Company, up to the present time in his capacity of vice president and general manager of the 80-mile transmission of the Southern California Power Company, now in active construction. Mr. Robert McF. Doble, Secretary and Treasurer, attained prominence on the electric transmission field through the active part he took in the building of the plant of the Blue Lakes Water Company, the engineering features of which were entrusted to Mr. Doble, then secretary of the company. He has recently, however, retired from the Blue Lakes Company to accept the presidency of the Abner Doble Company.

Messrs. W. Frank Pierce and John J. Seymour, as members of the Executive Committee, complete the list of officers of the Association, and of these, Mr. Pierce is president of the Blue Lakes Water Company. Though Mr. Pierce is practically a newcomer in the electrical field, he is, nevertheless, a most valuable acquisition as the engineering world will soon realize from the important part he will take in the installation of the proposed 110-mile transmission of the Standard Electric Company of California, to run from Blue Lakes City to San Francisco. Mr. Pierce is also a director of the Yuba Power Company operating the Yuba-Marysville transmission.

Mr. Seymour is a native of Ohio, and is a graduate of the class of 1877 in Civil engineering of the Illinois State University. For thirteen years thereafter he followed the profession of civil engineering, together with the kindred one of mining engineering, in Colorado and California, but in 1890 he became associated with the Fresno (Cal.)

Water Company, since which time he has been its president and manager. In 1895, he took up the financial end of the scheme suggested by Mr. John S. Eastwood for the electric transmission of power into Fresno from the headwaters of the San Joaquin River, and the success of his efforts is attested in the installation of the San Joaquin Electric Company that at once sprung into fame for being the then longest distance transmission, and for operating under the highest head—1140 feet—of any transmission in the world. Mr. Seymour's electrical knowledge and experience has been acquired since the inception and formation of the San Joaquin Electric Company, of which he is the President.

GIVE HONOR TO WHOM.

In each branch of science, as in every epoch of history, is recorded a name which, for some special attribute or boldness of action, stands as a mile stone along the pathway of time. Within the realms of electrical theory will be given to posterity, as they are revered to-day, the oft repeated names of Faraday, Maxwell and Henry among the dead, and of hosts of those among the living; within the realms of electrical practice who, aside from the master minds in the service of the great manufacturing companies, will stand prominent in the estimation of future generations for the substantial achievements of their abiding faith and for doing that which was necessary to finally place the science of electricity on the high plane of commercial utility where it will ever stand in the world's affairs?

Each branch of the science, whether in theory or in practice, or whether in telegraphy, telephony, illumination, transportation or transmission, or whether in other perhaps less important ramifications of electrical application, will furnish history with a master mind outshining, in matters of priority at least, all others. Every honor is cordially bestowed upon the designing engineers whose fertile brains have made possible the subjugation of nature's potent forces for the electrical transmission of power by high tension currents. Let us bestow, then, equal honor upon those far-sighted business men who early appreciated the utility of advances in electrical engineering and whose gold paid for the crucial tests without which electrical transmissions would yet be but interesting laboratory experiments.

The great west has furnished more than its quota of names that the future should revere as illustrious for their achievements in demonstrating the vital requisite of the commercial feasibility of electrical transmision of energy Fifteen, and even ten years ago the proposed long distance electric transmission of electricity for power or even for incandescent lighting purposes, was looked upon as perhaps remotely possible, or at best, as no nearer realization than is aeronautics to-day, and the non-technical man who ventured his money or that of his associates in such a project, did so under the inspiration of an abiding faith and generally amid direful forebodings. They are the true pioneers of electrical transmissions, and to them all honor is due.

The first electric transmission on the Pacific Coast was brought about through the untiring efforts of Mr. P. F. Morey, father of the Willamette Falls Electric Company, afterwards succeeded by the Portland General Electric Company, and who, early in 1888, installed a 4,000-volt transmission from Oregon City to Portland, 13 miles, the plant having a capacity of about 1250 horse power and being used for incandescent lighting purposes alone. Necessity for the delivery of power from the transmission circuits had become of paramount importance some six years later when Mr. J. B. Leggett, of the Standard Consolidated Gold Mining Company, of Bodie, Cal., after most disheartening delays and failures, succeeded in operating the mine and mill of that important property by single phase motors, the transmission being of 400 horse power, a distance of 12½ miles.

The possibility of reaping the advantages that would accrue from using higher voltages gave rise to the next important development, and early in 1893 the San Antonio Light and Power Company, under the presidency of Prof. C. G. Baldwin and the managership of Mr. A. W. Burt, placed its thirty mile line to San Bernardino and its fourteen mile line to Pomona, Cal., in operation for lighting purposes, utilizing 10,000-volts. This plant was, at that time, the cynosure of electrical engineers the world over, and it is interesting to note as exemplifying the rapid advance that has been made in transmission work in five brief years, that the step-up transformers of the San Antonio plant, which are still in operation as originally installed, consists of twenty transformers taking single phase current at 1000 volts from the generator in parallel, and delivering energy at 500 volts, the twenty 500-volt secondaries being connected in series, giving 10,000 volts to line.

The Bodie experience, though not unsatisfactory at the time, demonstrated the difficulties attending the transmission of power by single phase currents, but nevertheless Mr. Leggett proved, in a thoroughly practical way and under difficult conditions, that electric power could be relied upon—an idea which had, prior to that time, been gravely questioned. Single phase motors are, as all know, possessed of inherent drawbacks which made the announcement of the invention of polyphase motors more than welcome, and to Mr. H. H. Sinclair, of the Redlands (Cal.) Light and Power Company, is due the credit of installing in June, 1893, the first three phase plant for the transmision of power. Two years later Messrs. H. P. Livermore and Albert Gallatin had placed the Folsom-Sacramento transmission in operation and were delivering 4,000 horse power over a three phase, twenty-two mile transmission. After that, electric power transmissions found the way clear from a financial standpoint, as is attested from the great number of plants installed since, and those which were subsequent, merely followed along the well trodden paths beaten out by the pioneers of the art.

There still remained however, room for pioneering in the unexplored domain of higher voltages, for with the exception of the Newcastle-Sacramento transmission, installed by Dr. Charles Van Norden and operated at 16,000 volts, the potentials used have hovered about that iniatiated by the San Antonio transmission, namely, 10,000 volts. Mr. Sinclair was first to make public proof of his convictions in the practicability of operating transmissions at potentials above 30,000 volts, in the organization of the Southern California Power Company, which will be operating a 4000 horse power, 33,000-volt transmission over an eighty mile line into Los Angeles by September next, but while these developments have been transpiring, Mr. L. L. Nunn, of the Telluride Power Transmission Company has been quietly prosecuting practical experiments under most adverse climatic conditions with the view of determining the maximum potentials that may be made available for transmission purposes. He has constructed an experimental line, two miles in length, on a mountainous region subject to lightning, snow and sleet, and he has tried almost every conceivable form of insulator material and insulator, as well as potentials ranging up to 120,000 volts. With the extremely high potential named, it was not possible to hold it on the line in that locality, although it is believed that it may be held under more favorable climatic conditions—in fact, the trend of the experements is that no law as to permissible potentials can be given, as they will vary in each and every case with the conditions under which the transmission is to operate.

A convincing evidence of the conclusions reached is found in the interesting description of the Provo-Mercur transmission, from the pen of Mr. Leon W. Bly, first published as the leading article in this issue. From it will be seen Mr. Nunn's deductions that in Utah it is entirely practicable to use 40,000 volts for transmission purposes, despite the fact that some portion of the line traverses a mountain at an elevation of upwards of 9,000 feet above sea level. The Provo-Mercur transmission has been in satisfactory operation for four months or more.

Surely, then, Mr. Nunn is, of all others, the most noteworthy pioneer in the practical installation and operation of extremely high voltage transmission lines and his achievements in this direction have won for him well-deserved and enduring fame.

THE SALESMAN OF THE FUTURE.

The day is fast approaching, if it is not already here, when the salesman for the electrical manufacturing and supply house can no longer score triumphal success in working along the old lines of being "a boy among the b(hic!)oys."

Like all other branches of industry that at the outset depended upon vigorous exploitation, the pioneering times of electrical work had its period of individualism when the "personal equation," rather than the intrinsic worth of the apparatus, proved the turning point in the closing of a contract. Prices were realized which, in view of present values, now seem fabulous; and the importance of technical details were, in those early days, set at naught in blind but sublime faith in the ability of the installing engineer to faithfully execute each and every condition of a contract, however absurd or unheard of. With the engineer of that day nothing must be impossible of technical accomplishment; with the salesman, always of glib tongue and Bohemian penchant, it was more often the rule than the exception that his prime qualification consisted in an enormous capacity for hustling, story telling and riotous demeanor. In truth, the "old timers" will attest the fact many of the earliest electrical projects, now grown to giant corporations, were built in the shipyards of the banquet table and launched on the flood of its wines.

Now all is changed and the present time marks the era when the buyer is, or is fast becoming, as conversant with electrical engineering practices as is the seller. More than that, the seller generally knows his own apparatus thoroughly, while the intelligent buyer, and the buyer of any particular quantity of electrical apparatus is always intelligent, acquaints himself with the electrical and commercial features of each make of the variety of apparatus he is to buy before closing the contract. The time for "wool pullings" have passed and electrical machinery must now be sold by salesmen who are skilled engineers in both a practical and a technical sense.

Here is indeed an avenue of occupation for the hosts of highly trained electrical engineers that the educational institutions of the country are turning out each year.

Literature.

Any Book Published Mailed upon Receipt of Price by The Journal of Electricity.

"The Treatment of Disease by Electric Currents;" by S. H. Monell, M. D. Published by William Beverley Harrison; 8 vo., 1088 pages, 12 pages index. For sale by the "Emporium," price $6.

Like the previous volume by the same author, the book under present consideration presents some features of value, and some that cannot but be condemned. It is largely a compilation, and as such alone is to be commended, but unfortunately the author has seen fit to leave out the work of certain men, along various lines, that has been both scientific and of value; this is notably the case in the section on diseases of the eye, in which department there is no mention of the excellent work of Alleman, of Brooklyn, N. Y., on the treatment of leucoma. On the other hand the writer has collected and placed in one volume, the recorded facts in connection with the electrical treatment of a very large number of diseases, and has thus rendered no small service to those who are not sceptical of the value of electricity in treating conditions other than those found in the female pelvis. Dr. Monell has a certain amount of ability, but it is unfortunate that his writings are not rigorously edited by some one conversant with the terminology and fundamental principles of electricity. He is led, through lack of exact knowledge, into many errors which may not render the book less valuable to the practitioner, but which do certainly mar it as a sample of the teaching of medical men, on the subject of electricity.

As a text for the clinical instruction of the practicing physician, the book is of great value, for the directions are clear and explicit, and are given in a dictatorial tone that carries conviction to the mind of the average physician. Perhaps this is carried to too great an extreme and more claimed than one who has used electricity for any length of time will be willing to grant; but, on the other hand, many men have used electrical treatments for years and have failed to secure certain effects because they do not know anything of the fundamental principles of the agent they are using, nor are they conversant with the best methods of applying the remedy they would use. Many matters in the domain of electro-therapeutics are still open questions, and are bound to so remain until medical students are turned out with a knowledge of electricity that will enable them to intelligently undertake the treatment by electricity, of these conditions that are in the uncertain land.

The book has fallen into the customary sin of its predecessors on electro-therapeutics, and is loaded with cuts taken from manufacturers' catalogues. We fail to see why it is that all these books should have their pages marred by such cuts; yet the fact remains that no work on the subject, with which we are conversant, is free from this clumsy error in taste. The present work is quite the greatest sinner in this respect that has yet been published. Not satisfied with publishing these cuts once, many of them are repeated over and over again, sometimes the same cut being printed three times on two consecutive pages. One cut is repeated 105 timees and, by actual measure, takes up no less than 32 pages of the volume! Another is repeated 36 times, at a cost of over seven pages of space. And these are not cuts of any value, but are quite the contrary; the first referred to is an attempt to picture a simple pad, or indifferent electrode, and the second is a bi-polar electrode for the vagina. The frequent repitition of other useless cute consumes a total of some 60 pages, or more, and this without any advantage to the reader. Why publishers will persist in doing this sort of thing, or why writers will allow the use of such cuts in their books, is quite beyond comprehension.

PHILIP MILLS JONES, M. D.

Cards are out announcing the marriage of Miss Lucy A. Henning, daughter of Mrs. M. Henning, to Mr. E. M. Van Frank, at the Second Unitarian Church, San Francisco, on Tuesday, June 7th, and the host of electrical friends who attend the ceremony attest the high esteem in which the groom is held in the hearts of those of his chosen profession. Mr. Van Frank, as is well known, is general superintendent of the Sutro railroad and the most cordial congratulations of all are extended to him and his estimable bride.

Electro-Therapeuty

ON THE USE OF ELECTRIC CURRENT FROM CENTRAL STATIONS.

By PHILIP MILLS JONES, M. D.

DR. M. Hertzstein, of San Francisco, recently demonstrated the clinical aspect of a device for utilizing the 115-volt incandescent electric lighting current for certain medical purposes; the demonstration was principally along one line of work only, being the Doctor's improved method of examining the rectum and lower intestinal canal, but the principle of the apparatus has a very wide application in medicine. From the one piece of apparatus it is possible to obtain the appropriate currents of any and all uses which the medical man has for electricity, excepting of course the high tension currents derived from theinfluence or static machine.

The particular apparatus demonstrated by Dr. Hertzstein was made by Hirschman of Berlin, but the principle of the apparatus was developed and perfected, quite independantly, in this country by the writer.

It depends essentially upon what is known in electrical work as the "shunt circuit" the shunt being the fundamental principle of the entire device. A shunt circuit is a circuit formed by connecting two points of a closed circuit that are at different potentials together, thus forming a secondary path through which a portion of the current may pass; the voltage of the current passing in the shunt circuit will depend upon the voltage represented by the difference of potential between the two points of the principle circuit which are thus connected. Of course the maximum current obtainable in the shunt circuit will be determined by the resistance of the two circuits, and the maximum voltage, or difference of potential in the shunt circuit will be the voltage of the circuit from which the shunt is derived. If we connect the ends of a long straight wire to the terminals of the 115-volt lighting circuit, having such a resistance that about two amperes will pass, and then connect the leads from a voltmeter to two points on this wire, we will find that the voltage of the current passing through the voltmeter will depend entirely upon the distance between the voltmeter leads and that the current passing in the shunt circuit will have a direct relation to its voltage and the relative resistance of the two circuits.

Such being the principle of the apparatus, it is only necessary to know the various voltages and current strengths required in medical work in order to calculate the sizes of wire, proportions of the shunt circuits, points of attachment, etc. This the writer has been working upon for the last three years, a brief statement relative to it having been made to the San Francisco County Medical Society about a year ago.

The principle uses which the medical man has for electricity are as follows: For general treatment by the constant direct current employing up to 75 volts with a current strength of from one to two hundred milliamperes; for exciting the primary circuit of an induction coil for the purpose of obtaining the induced, or so-called "faradic" currents; for supplying current to small incandescent lamps for illuminating the cavities of the body that are not readily accessible; for heating electro-cautery knives; and for running small motors.

All of these various purposes may be subserved by the one piece of apparatus and with perfect safety and satisfaction, either singly or all at the same time; and further more the apparatus is permanent.

It is better to make the apparatus with two main circuits, one for the supply of current for the small lamps, faradic coil and general treatments, and the other for the electro-cautery. In this way a very considerable saving of current is obtained over the method of using but one main circuit from which all the various shunts are derived. The main circuit for the small lights, etc., is calculated to suit the nature of the work to be done, being as a general rule made of about eight hundred feet of German-silver wire, number 18, B. & S. gauge. The connections for the shunts are also calculated to suit the needs of the user and may be arranged to give any voltage from a fraction of a volt up to the maximum, 115 volts. The current strength in the main circuit just mentioned is about two amperes, the current required for two 32 c. p. lamps; this may be increased or lessened if desired or required.

The other main circuit is different in design and construction, owing to the fact that currents of very considerable strength are needed in this work of electro cauterization. The connections too are not the same for the reason that if a high voltage current is used in the strengths required to heat some of the knives employed by surgeons, an undesirable arcing occurs at the contact switch in the cautery knife handle. There are no fixed points from which the shunt currents are derived, but instead the main connection is switched to different points along the resistance wire of the main circuit, thus cutting out some of the resistance in the main circuit as the need for more current in the cautery knife arises. This is essentially the principle of the apparatus demonstrated by Dr. Hertzstein, with the exception that on his apparatus there is no connection for the so-called "galvanic" current treatment nor has the instrument any induction coil attached, the doctor preferring to have these on a separate apparatus.

It is almost obvious that any or all of these various currents may be used at the same time, if so desired, simply by making the proper connections and shunts; very often it is quite handy to have the means for illumination and cauterization available at the same time and without the necessity of making any changes in the connections or arrangement of the apparatus or wires. The current for a motor may be obtained from any of the connections by the simple use of a switch, or a separate connection may be placed on the switch-board at the time of construction.

The question of safety has arisen at various times and the writer has been frequently asked if this form of apparatus was perfectly safe and free from even the possibility of injury to the patient. There is really no danger in the use of the apparatus if the current supply is from the underground mains of the lighting circuit; if the current is furnished by over-head wires and there are any arc circuit wires on the same poles, it would hardly be safe to use this apparatus, but as almost all the wires are now underground the question of danger is practically nil. The device, as will be seen at a glance, admits of adaption to almost any form of a table, and the cost may be also a very variable item. If one desires to have marble and solid brass, together with the standard instruments for current measurements, he will have to pay for these things; if plain hard wood and no instruments will suffice, the total cost will of course be much less. Several forms of the apparatus have been made.

ON THE ORIGIN OF THE AURORA

By W. STUART-SMITH.

MR. Alexander McAdie, in the October "Century", writes entertainingly of the aurora, that dancing light of the polar skies which, since the mind of man first reached the stage of development which enabled him to formulate "why," has been a source of constant wonderment. One can well understand the awe with which the untutored mind of the savage would regard this light, which, without apparent cause, springs from the depths of night, and shoots its arrows into the darkness, silent, mysterious, well calculated to excite those feelings of superstition with which primitive man regarded all which his want of knowledge did not enable him to understand.

In discussing the origin of the aurora. Mr. McAdie cites the explanations offered independently by Bigelow and Paulson, namely, that the light is caused, in the upper regions of the atmosphere, by some transformation of ether vibrations which results in the production of luminous rays. In another part of his article he gives quotations to show that the light is sometimes very close to earth, in one instance instrumental measurement having located it at less than two-fifths of a mile above the surface; and the writings of General Greeley show that at the high latitude in which he made his observations it was almost within reach of a man standing on the ground. These facts indicate that the manifestations are not confined to the upper regions of the atmosphere, and that an attenuated condition of the atmosphere is not essential for their production. It is also stated that it is known that while they are from fifty to seventy miles high in latitude 50 deg., the height decreases as 68 deg. is approached—that is, as a higher latitude is attained.

It would seem that this statement is too broadly made, as it is based on a very limited number of observations. A glance at the polar projections of the heavens given in the "Century" article will show that the center from which the manifestations emanate is not located at the geographical pole, but is some distance south, and, while sufficient data is not given definitely to locate this region, there is little doubt that it is the upper Hudson Bay or approximate magnetic North Polar region. As this is far to the south of the geographical pole on the western shores of the Atlantic, it would seem that in naming the latitude at which the height of the aurora is observed, it is of the highest importance to give the longitude also. It is very probable that in the eastern part of North America and western part of Europe the aurora will be at a much lower altitude than in Western America or Eastern Asia; also that it will be seen much farther south. Indeed, that this is true the writer can confidently assert as he passed many hours, when a boy, watching the aurora as it appeared from his home in central New York, where the display was of frequent occurrence and often of great brilliancy, covering the entire northern heavens for many degrees above the horizon and sending steamers far toward the zenith. Since then he has passed many years on the shores of the Pacific, in approximately the the same latitude, both in America and Asia, and has never once seen any indication of the aurora. Also, it was his fortune to spend some weeks in November and December, 1882, and January, 1883, in Southern Patagonia, and saw no aurora, though those were years when it might have been expected. It will be noted that this region lies about the same with respect to the south magnetic polar region as North Pacific does to the magnetic pole of the North.

An assertion which can be made with the greatest confidence is that these luminous manifestations are sometimes seen close to the earth in places far removed from the magnetic polar regions. One evening during the last week in August, 1883, the writer was in Richfield Springs, New York, and saw bands of light slowly drifting across the main street of the village, but a few feet above the street. The length of street occupied was, perhaps, three or four hundred feet, the light in some places appearing as a sheet a few inches thick and in other places consisting of several layers with dark spaces between, the height of the whole being, perhaps, ten feet. The drift was through the trees on one side of the street, the tops of the trees being far above the light, thus clearly fixing the height. Later in the evening he was driving along a road about two miles out of the village and saw another similar display. The carriage was stopped and some time spent in watching the light slowly drifting directly overhead and certainly not more than twenty feet above the ground. There is absolutely no question about this being mist illuminated by stars or moon. It certainly was not this, but was unquestionably a self--luminous something slowly drifting in the atmosphere. The night was cool, clear and highly invigorating and where was some auroral display in the north. The light in question was, however, purely local in its character and was in small patches miles apart. It was in no manner connected with the auroral display of the northern sky though undoubtedly due to the same cause.

The "Century" article says that feeble displays are sometimes seen in the southern part of United States, but only at times of violent thunderstorm activity. If lights are seen when it is raining or the wind is blowing hard they may be caused by a brush discharge between clouds similar to the lights sometimes seen on board ship and known as St. Elmo's, but if there is violent lightning discharge between clouds while the atmosphere is quiescent the lights may be true aurora, as will be seen later. As far as the observations of the writer go, violent atmospheric disturbances of any kind are adverse to auroral displays, and probably rain or high wind at the point of origin would be fatal to them. Atmospheric quiescence seems not to be the only essential, as when auroral displays are seen the atmosphere is generally clear, cool and very invigorating. Feeble displays may some times be seen in a sultry atmosphere in case of violent lightning discharge, as noted above, though in such cases a sultry atmosphere is quickly cleared from causes to be mentioned later.

Looking again at the "Century" map of the heavens it will be seen that the light streams, starting from the magnetic polar regions, lie along the lines of force of the earth's magnetism. Observation shows that generally in the neighborhood of the magnetic pole they come close to the earth and are far removed from the surface in places comparatively remote from the polar regions. Is it not possible that consideration of these facts may throw some light on this wonderful phenomenon? There is a polar region where the magnetism is most intense; in this intense field and near where the lines of force enter the earth the intensity of illumination is greatest and frequently very near the surface. The greatest auroral displays occur at times of greatest sun disturbance as indicated by sun spots, also at these times there are heavy electric discharges and earth currents and greatest intensity of earth's magnetism, the variations becoming so great at times as to appropriately be termed electric and magnetic storms. The connection between the auroral displays and the electric and magnetic disturbances is certain; the manner of the connection unknown.

It has been suggested that certain motions of the ether are altered just enough to cause them to become luminous; but, as far as the writer knows, no explanation has been offered as to why such alteration causes the manifestations to lie along the lines of force of the earth's magnetism, or why they are most intense in those places where the magnetic field is strongest. It has, it is true, been suggested that the directive influence may be due to heavy currents of electricity passing through the atmosphere, but the atmosphere is not generally considered to be a good conductor, especially in the more dense portions near the surface, where the aurora is sometimes very brilliant. Perhaps no other explanation will be given, but an attempted explanation would certainly give due regard to all the elements of the atmosphere with view to determining whether any can in any manner be influenced by the earth's magnetism and, if so, whether such element or elements can be caused to exist in any peculiar state.

Examination of the atmosphere reveals the presence of oxygen in large quantities, and experiment shows this element to possess magnetic qualities in a high degree, and that it is, therefore, susceptible to the directive influence of the earth's magnetism. Examination shows no other considerable ingredient of the atmosphere which possesses the magnetic quality to any marked extent.

There is no reason for supposing that oxygen, in its normal state, can have its vibration period altered so as to become self-luminous except by increase of temperature, but further experiment shows that this element possesses the property of existing in a certain unstable state called ozone, and that in this state it possesses the properties which are foreign to it when in its normal condition. Also the peculiar molecular condition of oxygen in this state is brought into existence by electric discharge or by a dielectric strain which may or may not be followed by an electric discharge. Thus there is found in the atmosphere a substance which is susceptible to the directive influence of the earth's magnetism and which can be thrown into a peculiar molecular state in times of violent electric disturbance. In a quiescent atmosphere, oxygen in this state of molecular strain may float for some time, as would a body of vapor, and dispersion would be especially slow in a strong magnetic field capable of so directing the molecules as to make their mutual attractions add to the stability of the mass in virtue of the magnetic quality possessed by ozone.

Ozone as produced gives off no light that is manifest. Neither would a great mass of extremely small magnets show any sign of external magnetism if they were thoroughly jumbled together, but if the individual small magnets were free to turn on transverse axes and the whole were placed within a strong magnetic field they would be so directed as to form a large magnet with strong external field. Just so it may be that when all the molecules of a mass of ozone are directed by the influence of a magnetic field so as to assist one another instead of interfering, the mass will become self-luminous. Dispersion of the mass by rain or wind would cause the light to disappear. Such a directed mass of ozone might cause the local drifting lights seen by the writer, and in case of violent lightning discharge between clouds in a quiescent atmosphere the production of ozone might be followed by a faint luminosity after the molecules of the produced ozone had become directed by the earth's magnetism. This would explain the faint auroral displays mentioned by Mr. McAdie as sometimes accompanying violent thunder storms. In this connection it is to be especially noted that in clear, cool, invigorating weather, such as is common during auroral displays, the air is highly ozonized and the clearing of the atmosphere by thunder-storms is the result of the ozone produced.

Again, since the atmosphere consists to a large degree of oxygen—a magnetic substance, and since a magnetic substance tends to travel along magnetic lines of force toward those places where the intensity of the field is greatest, it may be expected that in the magnetic polar regions the percentage of oxygen in the air will be much greater than in places of weaker magnetic force far removed from the poles. Indeed, but for winds, probably magnetic action would cause the oxygen practically to displace all the other constituents of the atmosphere in the strong magnetic region near the poles, the atmosphere in those regions becoming nearly all oxygen.

Owing to the probably greater amount of oxygen in the atmosphere of the magnetic polar regions, the production of ozone will be greater there than elsewhere; that which is produced in the neighborhood of the polar regions will tend to move toward the accumulate there; the tendency to dispersion will be less than in other places, owing to the magnetic action, giving stability to the mass. Owing to all these causes the accumulation of ozone in these regions may become very great, especially in the higher altitudes out of reach of the more violent atmospheric disturbances. It would, of course, be greatest in times of great electric disturbance and great magnetic intensity, as these would be times of greatest production and maximum stability.

If aurora has its origin in masses of ozone, the swaying, folding and curving of the light may be caused by the movements given to the masses by air currents, and the shooting rays and sudden appearing and disappearing of the manifestations may be due to dispersion of the masses by gusts of wind followed by immediate redirecting by the magnetic force after the gust has passed. The colors seen may be due to light interference during the movements and partial disarranging of the mass.

Such spectrum data as the writer has been able to find shows evidence of the vapors of a number of substances, alway in a state of extreme tenuity. This is but what might be expected in the case of most substances, since they only exist in the atmosphere in very small quantities; but this might not be expected in the case of nitrogen, which constitutes so large a part of the atmosphere. Even this, however, is subject to a possible explanation. When the molecules of the ozone are magnetically directed, their mutual attractions are greatly increased owing to their inherent magnetic quality, and they will come together so as to increase the density of the mass. This movement will result in the displacement of non-magnetic substances to a very great extent, so that even close to the earth's surface nitrogen will exist in the mass only in a state of tenuity, and the spectroscope will so show it.

Mr. McAdie says there is one bright line which is always present in the spectrum of the aurora; the writer has not been able to find data showing the location of this line, nor has he been able to discover whether ozone shows any spectrum peculiarities not possessed by oxygen in its normal state. Probably it does. The matter is one easily determined by those having facilities for making the experiment.

The evidence in favor of the aurora having its origin in ozone may be summarized as follows:

We have as a considerable ingredient of the atmosphere a magnetic substance which probably exists in greater quantities in the magnetic polar regions than elsewhere, especially in calm weather; we find that this magnetic substance is capable of existing in a state of molecular strain when it possesses properties very different from those common to it in its normal condition; we find that this peculiar state of strain is produced whenever there is an electric discharge in the magnetic substance, or when there is a state of intense dielectric strain which may or may not result in electric discharge; we find that when a mass of this magnetic substance in this strained state has its molecules directed by a magnetic field, the mutual attraction of the molecules of the mass should cause it to have a certain amount of stability which will prevent easy dispersion; sometimes during thunderstorms when violent electric discharges are certain to result in the production of the molecular strain in considerable masses of the magnetic substance, feeble and sporadic displays of aurora are seen; we find that at certain regular periods great disturbances occur in the sun, and that these disturbances are accompanied by violent electric and magnetic changes on the earth, and that electric discharges take place or dielectric strains are set up such as may result in the strained condition of large masses of the magnetic ingredient of the atmosphere; we find a probability of there always being a considerable amount of the strained magnetic material in the polar regions, especially in the upper regions of the atmosphere, away from the dispersive influence of the wind; also there is every probability that the amount of strained material in the polar regions is very great during periods of great sun disturbance, both because the production is greater during those periods than at other times, and because there will be a great tendency to accumulate owing to the magnetic field being more intense during those periods than at other times; finally, there is generally some aurora to be seen in the polar skies, the brilliancy becoming a maximum during periods of great sun disturbance. There must be some fire beneath all this smoke.

ELECTRICAL ENTERPRISE IN WESTERN TOWNS.

The far western parts of the United States—that is, the part west of the Missouri river—is a country full of enterprise. Fancy a Russian, or even a German or British town of 1500 inhabitants, ordering an electric light plant which would have to be hauled over mountainous bridle paths for 150 miles from the nearest railway station before it reached its destination! Yet this is what the town of Lander, in Wyoming, had the courage to do, each mule employed taking twelve days to make the round trip between Bitter Creek, on the Union Pacific Railway, and the town whose progress was apparently impeded for want of the latest and most expensive means of artificial illumination. The town of Sheridan, also in Wyoming, had only 600 inhabitants and was 200 miles from the nearest railroad when it discovered that an electric light plant was essential to a continuance of its self-respect. Accordingly the plant, packed in very small pieces, was hauled 200 miles, and Sheridan was happy. Since then this town has had a stroke of luck, for the Burlington Railway, pushing its way toward the Yellowstone River, has gone rght through it, thereby increasing its population at a single bound from 600 to 1000. Buffalo, another town in the same State, having 600 inhabitants, thought 44 miles a comparatively short distance to haul its electric light plant.

In the adjoining State of Idaho, the important town of Lewiston, with 2000 inhabitants, had its electric light plant hauled on boats for 80 miles up the Snake River. Murray, with 700 inhabitants, had a 60-mile overland passage to accomplish, or about the same length that Silver City, with a hundred less population, hauled its electric light plant. Turning now to places situated on the railways it is found that Newcastle, Cambria, Rawlins, Rock Spring, Green River, and Evanston, in Wyoming, and Pocatello and Idaho Falls, in Idaho, have each an electric light plant, though the population of not a single one of these towns exceeds 300. Boise City, Idaho, as befits a town puffed up with 8000 inhabitants, has not only an electric light plant, but a system of trolley cars.

Moreover, as some natural hot springs happen to be close to Boise City, the citizens heat their houses with the hot water from them, and even raise early spring vegetables by using the hot springs for irrigation purposes. The three small mining camps of Coeur D'Alene, Wallace and Wardner use electricity for lighting purposes all the year around, while their available water supply is used to run the mills for stamping ore. But in winter when the main water supply is frozen, the electric current is connected with the stamping mills, and lighting and power is furnished by a lavish expenditure on coal at $10 a ton.—Cassier's Magazine.

WATER POWERS OF ELDORADO COUNTY.

The question of power is always one of pressing importance to a mining section. In this respect El Dorado county is well provided for, as in a number of places water is available as a source of power, and in a greater portion of the county wood is still cheap and plentiful enough to render steam an economical power, but in view of the advances which have been made in the application of electricity as a motive power, especially in mining, it is evident that it is the coming power in El Dorado county, as well as elsewhere. Such being the case, El dorado county has the solution of the power question within its borders, as its streams are capable of developing sufficient power to run the State.

No portion of California has a finer water supply than El Dorado county. The Middle and South Forks of the American and the various forks of the Consumnes, together with their tributaries and mountain lakes, the majority of which are situated favorably for storage purposes, form an unsurpassed water system, one capable of supplying not only the needs of the county, but those of Sacramento, Contra Costa, and Alameda counties. The topography of the country is such that water can be carried by ditches to all but a small part of it.—Placerville Democrat.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

THE "ELECTRA" CARBONS.

Mr. Hugo Reisinger, No. 38 Beaver Street, New York, sole agent for the celebrated "Electra" Highest Grade Nuernberg Carbons, desires the publication of the following notice in refutation of statements recently made in trade papers:

"I wish to inform the trade that the word 'Electra' has been properly registered by me as my trade mark and therefore, can not be used by anybody else without infringing on my rights. The 'Electra' carbons are made, as heretofore, by the world renowned firm of C. Conradty, Nuernberg, who owns not only the oldest, but the most extensive carbon works in existence and whose carbons remain unequalled in quality and efficiency, having become the standard for electric lighting the world over. As to parties reported as makers of 'Electra' carbons, I wish to state that I have brought suit against them for having misused the trade mark, 'Electra,' and that they have been enjoined by the Nuernberg courts from making any carbons stamped 'Electra,' under penalty of 100 Mks. for each carbon. I shall guard the interest of buyers of my carbons as heretofore, and any information in regard to infringements on the registered trade mark, 'Electra,' that will enable me to take legal proceedings, will oblige."

The following self-explanatory letter from Mr. Reisinger's attorneys is also given, and will be read with interest by all users of carbons for constant potential arc lamps, and particularly by those who prefer the use of the genuine "Electra" carbons to all others. The letter referred to is as follows:

New York, January 4th, 1898.

Messrs. Schiff, Jordan & Co., 232 Greenwich St., City.

Dear Sirs—Mr. Hugo Reisinger, of this city, who has the sole right of dealing in the carbons known as "Electra" carbons, has shown us your advertisement in the "Electrical World," in the number of January 1st, and on page xi, in which you refer to Julius Fuchs at the manufacturer of the "Electra" carbons, and you state that that product will, in future, bear only your trade mark, "Schiff Carbons." We have advised Mr. Reisinger that such use of the trade name "Electra" is illegal, and in violation of his sole and exclusive right to the use of that trade name in connection with carbons. On further reflection you will probably see that any illegal use of that word, in the past, by Julius Fuchs for the purpose of securing a trade and popularity for the carbons of his manufacture, when sold under that name, can not be transferred to the same carbons by notifying the public that the same carbons, formerly sold, will be sold under the new name. You must start with your new name, without reference to the name "Electra," which you have no right to use, and the prohibition in respect of which upon Mr. Fuchs, Mr. Reisinger is informed that you have been and are fully aware. Under these circumstances, Mr. Reisinger desires to notify you that you must at once desist from all use of the word "Electra" in connection with carbons, no matter what form it may be. The advertisement referred to above must be at once cancelled and withdrawn and all other advertisements in which such reference and use of the word "Electra" is made. We shall be glad to receive a letter from you promptly, giving us assurance that Mr. Reisinger's reasonable desires above expressed will be complied with. ......

(Signed) WETMORE & JENNER.

EVIDENCES OF STURDY GROWTH.

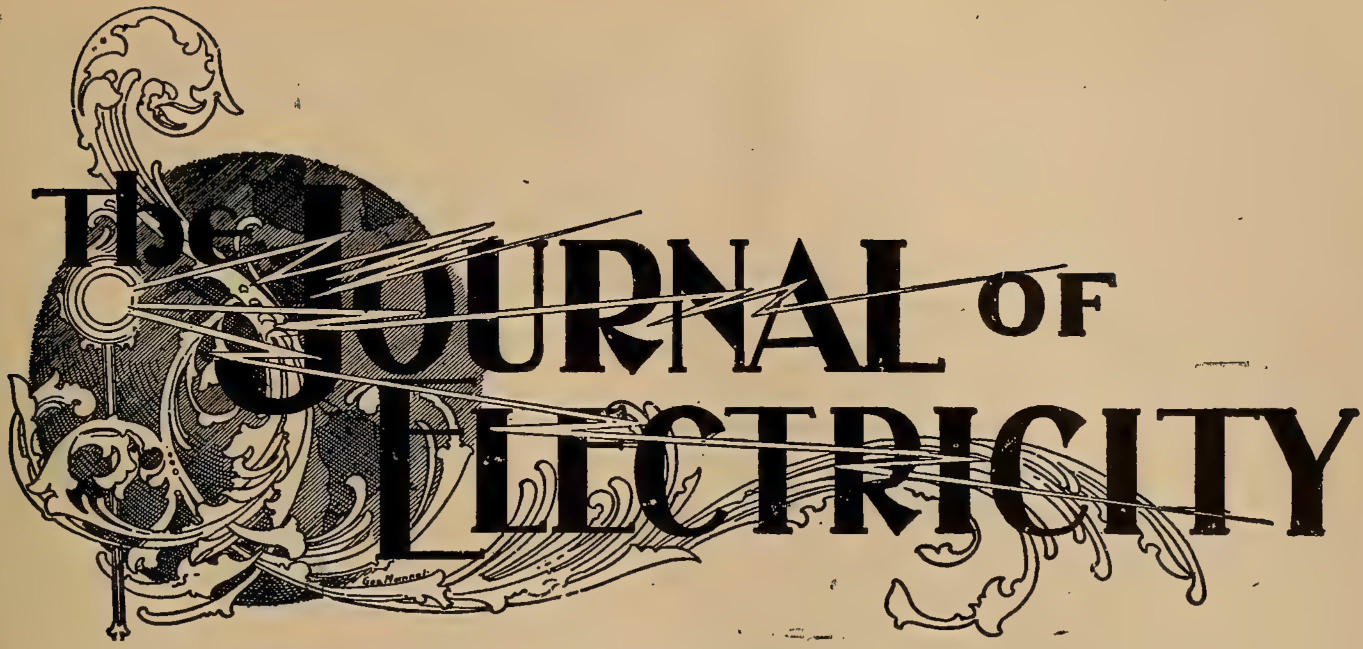
The General Electric Company in view of the constantly growing demand for apparatus of its manufacturing, has decided to make a large increasein its manufacturing facilities. March 25th, the Company played contracts for the construction at its Schenectady Works, of a new foundry which will be one of the largest in this country. The present foundry has been for some time entirely inadequate to meet the demands upon it, and considerable work has been passed on to the admirably equipped foundry which the Company has at Lynn and Schenectady foundries, working orevtime and all is now to be concentrated in the new foundry, construction of which is to be begun immediately. .. ..

The building will be of brick, 500 ft. long and 140 ft, wide with an "L" 100 ft. by 120 ft The latter will be used as a cleaning shop. Besides these main buildings a number of sand sheds, several smaller buildings for the storage of foundry material, and a new pattern store house 200 ft. long, 60 ft. wide and two stories high, will also be erected. All combined, the floor space occupied will be about 12,000 sq. ft. Plans are also under consideration for a new machine shop, 650 ft. long by 165 ft. wide, but the appropriation for this has not yet been authorized.

The building will be erected on the recently purchased property lying to the West of the present works and parallel with the Erie canal. The foundry will be built several hundred feet from the canal and will have in close proximity the sand sheds and pattern store houses. Every precaution will be taken to eliminate risk from fire; indeed the pattern storehouse will be made as absolutely fire proof as possible. The foundry, as laid out, will be a model of the most approved modern practice. Careful thought and study have been given to the matter, and the Engineers of the Company have drawn on the experience of other Companies which have recently constructed foundries. The building will be of imposing proportions, and will be in plain view from the New York Central tracks.

The contemplated machine shop will be built on the Central Avenue opposite building No. 15, and will be devoted almost entirely to very large machine work. The size of the great generators which the General Electric Company has been manufacturing, has of late been increasing until, to-day, a generator of 4000 h. p. is not now regarded as of unusual size. In fact, generators of 5000 h. p. are now in course of design, and the demand upon the shop in which the large machinery has heretofor been built has far outgrown its present proportions.

The middle aisle of the new machine shop will be 65 ft. wide, with narrower aisles down each side. Electric travelling cranes will be installed to operate along each aisle and a gallery will be built along one side only. All the large machine tools will be removed from their present locations to the new shop, their places being taken by smaller apparatus. The total floor space of this building will amount to not less than 144,250 sq. ft.



The Journal of Electricity

* * *

VOLUME VI

* * *

JULY-DECEMBER

1898

* * *

SAN FRANCISCO, CAL.

INDEX TO VOLUME VI.

Illustrated articles are designated by an asterisk (*); Editorials by a dagger (†); Passing Comment by a double dagger (‡), and Industrial by a section mark (§).

PAGE

Authors

- Bly, Leon W. 5
- Burch, Edward P. 72
- Burkholder, W. A. 49
- Gray, Prof. Thomas 55
- Howard, John L. 51
- Lewes, Prof. Vivian B. 124
- Lohmann, R. W. 65
- Low, Geo. P. 25, 81
- Poole, C. O. 70
- Richards, John 8
- Scott, Charles F. 113
- Stuart-Smith, Lieut. W. 57

Editorial

- A New Dress 19
- European Industrial Conditions 18
- Sister Sciences, yet Estranged 38

Electro-Economics

- ‡ Cost of Producing Electricity 19
- † Efficiencies, Actual and Theoretical 18
- * Some Possibilities With Electric Plants, by C. O. Poole 70

Electro-Therapeutics

- Anæsthesia Electrically Induced 20

Financial

- † The Influencing of Stock Values 39
- To Reduce General Electric Share Capital 9

Gas

- Acetylene—I, by Prof. Vivian B. Lewes, F. I. C., F. C. S. 124
- ‡ American News From a Foreign Source 55
- The Pacific Coast Gas Association 17
- Properties and Dangers of Acetylene 46
- Rubber will not hold Acetylene 41
- World's Largest Gas Engine 80

Hydraulics

- Concerning the Quimby Pump 45
- Hydraulic Equivalents 125
- On the Electrical Operation of Conoidal Centrifugal Pumps, by John Richards, M. E. 8
- * A Thirty-foot Impulse Water Wheel 111

Illumination

- Accumulator Variations and Acid Strength 37
- § A Meritorious Incandescent Lamp 48
- * Electricity in the Schilling Gardens, by R. W. Lohmann 65
- * Electric Storage in an Edison Station, by Geo P. Low 25
- *§ Improved Brush Arc Lamps 78
- *§ Miniature Arc Lamps 112
- *§ The Latest Fort Wayne Arc Dynamo 64

Industrial

- Central Electric Company in the West 80, 125
- Electrical Supplies of Every Description 24
- Leather Belts for Dynamo Service 79
- Something New in Motors 125
- Two Mammoth Contracts 47

Literature

- Electricity in the Diagnosis and Treatment of Diseases of the Nose, Throat and Ear, by W. Scheppegrell, A. M., M. D. 108

Miscellany

- An Exponent of Progress 108
- Some Letters to the Editor 125

PAGE

Mining

- *Electricity in Mining—III
  - Lighting of Mines 22
  - Auxiliary Power in Mines 23
  - Operative Power in Mines 24
- Electricity in Mining—IV.
  - Operative Power in Mines—Concluded 40
  - Historical 40
- Electricity in Mining—V. 109
  - * Direct Current Hoists in the Montauk Mine 109
- Electrolysis in Copper Refining 41

Obituary

- Dr. John Hopkinson, F. R. S. 73

Passing Comment

- A Noteworthy and Striking Article 19
- Roehle's *Digest* Suspends Temporarily 106
- *Science Abstracts* 40
- Street Railway Publications 55
- Turning a New Leaf 55

Personal

- Babcock, A. H. 37
- Bell, Prof. A. G. 57
- Brayton, Wm. S. 36
- Breyton, A. P., Jr. 57
- Breyton, E. L. 37
- Briggs, W. W. 73
- Brooks, J. W. 36
- Burkholder, W. A. 37
- Cory, Prof. C. L. 17
- Crocker, Prof. F. B. 56
- Duncan, S. A. 36
- Doble, Robert McF. 107
- Dutcher, C. E. 107
- * Elder, R. B. 107
- Francis, Ira G. 17
- Freeman, C. E. 36
- Forst, E. H. 17
- Gilbert, C. P. 107
- Honnold, W. L. 56
- Hunt, A. M. 107
- Keith, Dr. N. S. 36
- * Lighthipe, J. A. 21
- Lloyd, C. R. 37
- Macdonald, T. H. 36
- * Masson, R. S. 36
- McAdle, Alexander G. 36
- Meredith, Wynn 16
- Morey, P. F. 57
- Neisser, A. I. 73
- Osler, M. L. 37
- Perrine, Dr. F. A. C. 36
- Scott, Chas. F. 36
- Sharp, E. C. 17
- Sipe, M. T. 17
- Stuart-Smith, Lieut. W. 36
- Tandy, L. D. 112
- * Theberath, Theo. E. 56
- Van der Naillen, Prof. A. 107
- Woodward, I. C. 107
- Wybro, H. C. 36

Physics

- † A Look Into the Future 54
- ‡ Electric Properties of Glass 20
- Electrolysis of Water 77
- Energy Received from the Sun, by Prof. L. G. Carpenter 125
- Lighter than Hydrogen 37

Steam

- Coal Combustion and Smoke Prevention, by John L. Howard 51
- † Petroleum in Southern California 19

INDEX TO VOLUME VI.—CONTINUED.

PAGE

Telegraphy

Wireless Telegraphy in Commercial Service 35
Japan as an Electrical Center 73

Telephony

Arc Lamps as Telephones 37
‡ A Telephone Magazine at Last 106
‡ Picture Transmission by Wire 39

Trade Literature

A Review of Industrial Catalogues 64, 80, 125

Transmission

A 1000-horse-power Induction Motor 64
Calculating Three-phase Circuits 73
*§ Electric Motors in the Stable 20
† Electric Power in the Pressroom 123
* High-Voltage Power Transmission, by Chas. F. Scott 113
† How Shall We Drive Exciters? 74
† Insulators, as Viewed by a Contemporary 38
† It is Original, Undoubtedly 54
‡ The Limitations of Power Transmission 123
* Measuring Three-phase Circuits 77
* The Mechanicville-Schenectady Transmission 57

PAGE

Moisture on High Tension Insulators, by Lieut. W. Stuart-Smith 57
‡ Noteworthy Current Transformations 105
‡ Over-conservatism in England 75
Paralleling Large Alternators, by Edward P. Burch 73
† Polyhase Current Distribution 104
* Polyphase Induction Motors 34
Proceedings of the Second Annual Convention of the Pacific Coast Electric Transmission Association 10, * 42
Random Notes on Extremel High Potentials by Leon W. Bly 5
* The San Gabriel-Los Angeles Transmission, by Geo. P. Low 81
† Scott on High-Voltage Transmission 122
The Snoqualmie Transmission 80, † 104
Starting Non-Synchronous, Single-Phase Motors 37
Substitutes for Copper as a Conductor 77
Synchronous vs. Induction Motors 76, ‡ 1 6
‡ Tesla's Lineless Power Transmission System 123
† The Burial of a Bugaboo 74
The Ratios of Rotary Conversions 108
§ To Prevent Line Leakage 17

Transportation

* Building the Tramway Over Chilkoot Pass, by W. A. Burkhoider 49
* Electric Traction Discounts Steam Haulage 47
Rheostatic vs. Series Parallel Control, by Prof. Thomas Gray 55
‡ Statistics Concerning Electric Railways 75

One Dollar per Year! *Do You Subscribe?*

THE JOURNAL OF ELECTRICITY

Official Organ Pacific Coast Electric Transmission Association.

ELECTRICITY
STEAM : : : : WATER
GAS

Address:
427 Tenth Avenue,
San Francisco, Cal.

THE JOURNAL OF ELECTRICITY.

VOLUME VI. SAN FRANCISCO, JULY, 1898. NUMBER 1.

*Random Notes on Extremely High Potentials.**

BY LEON W. BLY.

SOMEWHAT of mystery, even to transmission engineers, exists concerning what is now termed extremely high potentials—that is, pressures ranging from 30,000 volts and upwards—and the fact is that very few men have had any actual continuous experience with potentials higher than 20,000 volts, while with very few exceptions, experiences have been limited to the operation of pressures ranging from 10,000 to 15,000 volts. Nevertheless, experiments with extremely high potentials as defined, have been quietly prosecuted west of the Rocky Mountains with a thoroughness that has undoubtedly been unequaled elsewhere, for as early as in the summer of 1896 power was effectually transmitted over a two-mile circuit under a pressure of 60,000 volts. The results, however, have been carefully guarded, and very little, if any, of the details of the important and expensive tests then made have been given to the public. Efficient and reliable generating and distributing apparatus of different makes can be found in the market, but for long distance work, the all-important and most difficult problem that confronts the engineer is that which leads to the determination of the highest voltage that it is practical for him to use after taking into consideration the loss of power, the cost of line and transformers, and the liability of interruption to service from the breaking down of either transformers or line. The difficulties attending the long distance transmission of power of extremely high potential, must therefore be laid at the door of these two most important and really vital parts of the equipment, namely, the transformer and the line, and it is under these two heads that the random observations brought out in this paper naturally resolve themselves.

THE CLIFF HOUSE, SAN FRANCISCO. WHERE THE PACIFIC COAST ELECTRIC TRANSMISSION ASSOCIATION HELD ITS SECOND ANNUAL CONVENTION.

Some electrical manufacturing concerns express willingness to build transformers for pressures as high as 50,000 volts, professing to guarantee them, but I think it will be found that these guarantees will not be of a satisfactory nature for pressures above 35,000 volts; at least this is a rational conclusion from the fact that no manufacturing company has installed transformers that are in practical operation at these pressures in regular commercial work. Where every effort has been made to secure such satisfactory guarantees, the buyer eventually finds that he must assume responsibility for the success of the undemonstrated experiment he undertakes in insisting upon the use of extremely high potentials, as the manufacturing company will take no responsibility for loss of business or other damages resulting from breakdowns. While it may be generally believed that these high pressure transformers are a comparatively unreliable piece of apparatus, a proof of what they are capable of doing is demonstrated by the 40,000-volt transmission over the thirty-two mile line between Provo Canyon and Mercur, Utah, which has been in successful operation since early in March last. A description of this interesting transmission will be found in The Journal of Electricity for June, 1898.

---

*A paper read before the Second Annual Convention of the Pacific Coast Electric Transmission Association, held at San Francisco, Cal., June 21, 1898.

To effectually insulate is, of course, the most important feature in high tension transformer design and building. The problem presented therein with commercial transformers operating at 60,000 volts, is by no means an easy task, and the success attained will depend largely on actual experience drawn from long and practical observation in transformer manufacture and operation. Believing that information along this line will be of value, I will endeavor to give a few points concerning features that I consider to be of good practice in attaining the highest insulation in this class of apparatus.

The suggestions offered are the results of practical observation and experience under actual working conditions, which has taught well the lesson that the installation and operation of transformers under these pressures are exceedingly sensitive and difficult, especially when the requirements for high efficiency necessitate such compactness of design as to throw serious obstacles in the way of attaining high insulation. I contend that the accomplishment of extreme high efficiencies in transformers of this class is not desirable at all times, for its attainment is only accomplished at the expense of reliability. The reason for this is simple: the highest efficiency in transformers is secured when the iron and copper circuits are of the least possible length, or in other words, when the insulating space is reduced to the least possible degree. The requirequirements for high insulation necessitate a form of construction that will give a high safety factor to the dielectric between coil and coil and each coil and the core, taking full consideration of the potential difference existing between these parts. I repeat, therefore, that the additional gain of say, of one per cent. in transformer efficiency is attained only through the serious impairment of its insulation, which in this case, is synonymous with unreliablity, and that, conversely, the loss of one per cent. in transformer efficiency is apparent and not real when it is the direct means of cutting down the line loss from, for instance, ten per cent. to five per cent. In other words, transformer and line losses in all transmission work, should be considered collectively and not individually. To emphasize this point still further it may be stated that a transformer delivering 60,000 volts will have an efficiency that is one per cent. lower than a transformer delivering 30,000 volts, but by doubling the voltage delivered, we have secured a line loss of but twenty-five per cent. of that which would exist were the lower voltage applied to the same line. Further comment on the necessity for attaining the maximum efficiency of the transmission system as a whole, rather than of the transformer as a separate factor, appears unnecessary.

Oil is indispensible as an insulating medium in extremely high pressure transformers, principally because of its much greater resistance to discharge than is possessed by the dielectric properties of air. As a rough example, one-eighth of an inch of mineral seal oil will require, with an alternating current of sixty cycles, a little over 20,000 volts to puncture it, which is, perhaps, six or eight times the potential required to jump across an air gap having the same separation. Right here may be stated the conviction that the use of air is impracticable as a medium of insulation on high tension transformers.

The space surrounding high tension coils as well as the insulation between turns and layers, should be laid out with a liberal safety factor for the difference in potential at that point. A very good practice in this regard is that used on some high pressure transformers recently placed in operation in which the coils were set upright, that is, the iron openings were placed in a vertical position, as were also the insulating strips, in order that the circulation of the oil may be facilitated. Some temperature tests on these transformers show the temperature to be fairly uniform throughout. Hard wood, such as maple or walnut, when properly treated with the oil used in the transformer, forms one of the best materials that can be used to support the coils; in fact where a solid insulation must be used within transformers, wood is the best material, as it not fragile, is easily worked into any desired form, and it is a good insulator for high pressures when immersed in oil.

The bringing out of terminals constitutes another difficult feature in the transformer building, and heavy insulation such as glass or porcelain tubes are desirable, while for the terminal block again wood forms the most serviceable material as it is far superior to marble. It is advisable, however, that the terminal block of wood should be under the surface of the oil, especially if the terminals are numerous, or exposed to high potential differences. In taking the terminals out through the tank it is advisable to lead them through the top, care being taken to avoid the case, and to keep the high tension and low tension terminals well separated. Some manufacturers favor bringing the low tension leads out through the side of the tank, which is commended. The necessity for taking the high tension terminal through the top of the transformer is evident, for the reason that in so doing there is less liability of personal injury by contact. The leads may be more easily given the wide separation that is necessary when carried through the air; the terminals may be carried up through glass or porcelain tubes incased in wood set into the top of the tank, and a wide area of insulating material may intervene between the terminals and the tank cover so that sparking over from terminal to tank will be prevented.

Fullerboard forms one of the most desirable materials that are used in transformer building on account of its uniformity of surface and insulation. It is easily fitted any desired shape; it is flexible; it may be obtained in large sizes, which makes it superior to mica, and it is an excellent insulator.

It is of course necessary to divide the high tension coils up in many sections in order to reduce the difference in potential between the layers, and yet, sometimes it has been found that after splitting up the coils, trouble was experienced from the sparking over at the ends of the coils between the layers. This difficulty is overcome by the ingenious design of some high tension transformers recently constructed, in which a strip of insulating material consisting of a cotton cord of the same diameter as the wire, was wound on the edge of either end of each layer, thus preventing a discharge across the end of the insulation separating the layers. My observation has led me to believe that many unaccountable breakdowns of high tension transformers is the result of carelessness in properly assembling and holding into place. Muslin seems very desirable for use in binding together the coils as well as wrapping them before binding them together, to hold all insulation between turns, etc., in place. When some solid insulation, such as fullerboard, is used in addition to the oil and other insulation surrounding the coils, it is no doubt a very good practice to let it extend well out beyond the edge of the coils, as it might prevent any piece of conducting material, accidentally getting into the transformer, from causing trouble.

When oil is used, one can take advantage of its heat conducting properties to get larger radiating surface by properly corrugating or in some way increasing the surface of the tank, and so be able to dispense with extra appliances for cooling. But where it is found necessary to use water coils for cooling, the proper place for the coil is near the surface of the oil, and not extending through to the bottom of the tank as is the practice of some manufacturers, for the reason that, as the hot oil rises to the top, the cooling coil should be placed at the top where its influences are desired, and not extend through to the bottom, which makes the whole transformer relatively cooler. The latter practice causes the transformer to work under uneven temperature.

Another error which the experimenter in extremely high potentials is liable to fall into is in the design of the building for the high tension apparatus. A liberal allowance in space for high tension leads, switches, lightning arresters, and long break switches should be made to eliminate possibility of trouble, and where high tension leads are taken through walls of buildings, they should be carried through insulating panels with ample separation between the wires. I believe the practice of taking line wires out from stations through such panels to be superior to the ordinary mode of leading them out through openings in the wall, for the reason that by enclosing the openings and putting a gable over the enclosing panels, the insulating supports of the high tension circuits within the building are freed from the insulation impairing proclivities of the outside atmosphere. These insulating supports are necessarily closer together within the building than is required in outside work, hence the necessity for giving them greater protection against the atmosphere.

A consideration of the features of transformer design and operation would be incomplete without reference to the protection of transformers from lightning, but as my experience has been limited to but one form of arrester, namely, the Wurts, I do not feel qualified to discuss the qualifications of the various types; nor could I add to the literature existing on the subject. I must acknowledge, however, the comparative success that has attended the use of these arresters on the extremely high potential lines that have come under my observation.

The subject of transmission lines has proven a fruitful source of discussion, and many of the details of line construction have settled into such well defined lines of efficient practice that they do not appear susceptible of material improvement. Details of line calculation and of mechanical features, however, are points upon which little can be said that is new, but the practical experience of those who have handled the extremely high potentials with which this paper deals, is that the electrical transmission of energy at the higher potentials necessitates considerable difference in practice from the transmission of potentials ranging between 10,000 and 20,000 volts. Some of these differences will now be briefly touched upon.

As to insulator materials, porcelain punctures more readily than glass, and in addition, it is becoming realized that the porcelain within an insulator may be considered as forming a solid well suited for the support of the insulating glaze; glass, however, is homogeneous throughout, its puncture resisting qualities are high, and withal, when first cost is considered, glass forms an insulator which is preferable to porcelain, if the fact of its more general use on transmission lines is accepted as conclusive. Leaving out the respective merits of glass and porcelain, however, the prime qualification of a reliable insulator for extremely high potentials may be summarized in general as mechanical strength, largest possible dry surface between wire and pin, and of puncture resisting material. To my mind, however, so much attention has been given to the study of the design and characteristics of insulators that the importance of the equally vital device found in the supporting pin has been largely overlooked. As a result, the insulator has approached a fair degree of perfection, but the pin has been more backward in its development. I want to emphasize the belief that, in extreme high tension work, it is a grave mistake to consider the pin as any other than an integral part of the insulator. It is not a part of the cross arm, and being a part of the insulator, it must be of the best insulating material suitable for its purpose. In fact, the pin possesses an importance almost equalling that of the insulator itself, and any feature which impairs the qualities of the pin as part of the insulator, seriously weakens the permanence and reliability of the line.

It is for this reason and others, that my experience has led me to look with distrust upon all supporting pins consisting of or containing iron bolts. These iron pins are used only to give added mechanical strength, but they accomplish this at the cost of introducing a conductor into the weakest part of the insulator, inviting puncture and the troubles consequent thereto. Puncturing and the burning off of pins at the point opposite the lower edge of the inner petticoat, constitute the two serious troubles to be looked for, and the occurrence of both these troubles may be attributed to the fact that the supporting pin is of conducting material. Many efforts have been made to produce an insulator giving a high resistance to puncture, and porcelain base pins have been introduced to prevent the burning off of pins, but to my mind it would be greater wisdom to remove the cause of the trouble—the conducting pin—than to attempt to devise a remedy for it while still permitting the cause to exist. To carry a steel pin clear up into the body of the insulator maintains a constant invitation to puncture. The easiest way to accomplish a thing is the best way; and I believe that the elimination of troubles due solely to the conductivity of pins, may be effected satisfactorily by substituting strictly non-conducting pins for pins that conduct high tension currents in stormy weather. Prepared wood pins have been found to be very satisfactory for extreme high tension work.

Bearing in mind that the pin is a part of the insulator and not of the cross arm, it may be said that the chief qualifications of the insulator are, first, ample width to keep the pin and under petticoats as dry as possible; second, ample separation or elevation from the cross arm to prevent leakage from following the drops of moisture; and third, ample dry surface in corrugations around the crown of the insulator—in addition to the dry surface on the inner petticoats—to break the circuit formed by moisture or rain from line direct to cross arm. These qualifications should be combined with mechanical strength and durability.

In practice it has been found that the separation between transmission lines is not done with the idea of preventing short circuiting or cross leakage so much as it is to reduce the capacity of the line, and in extremely high potential work the difficulties consequent to increase in capacity will be found of constantly increasing seriousness as the potential raises, and the most efficient mode of reducing capacity is by separating the lines. The effect of capacity may develop into an important factor and demands careful attention, especially on extremely long lines at extremely high potentials. By introducing a reactance into the circuit, this can be practically neutralized, but a system thus balanced and containing great capacity and reactance, may be very difficult to regulate, as its balanced condition will be affected by many factors, some of which are uncontrolable. For instance, a change in the load, or a change in the power factor of the load, or a change in the atmosphere, will affect its unbalanced condition.

Much further might be said concerning work of this class, but I will only add that with whatever elaboration the functions of an extremely high potential transmission line may be figured out, the installation when completed will prove that no exact dependence can be placed on the theoretical deductions, for the reason that the factor of capacity is one that varies with practically every atmospheric change, and more especially with the influences on capacity from varying power factors due to changes in load.

I must add, in conclusion, that the treatment of what may be called the phenomena of extremely high potential practices, which, in a very superficial way, is what this brief paper is intended to be, should not be confounded with experiences had in the operation of the lower potentials of from 10,000 to 20,000 volts. As intimated, the opinions here given are mainly of a general character, for the present paper only sets forth a few random observations on extreme high potential workings.

⁂

On the Electrical Operation of Conoidal Centrifugal Pumps.[*]

BY JOHN RICHARDS.

CENTRIFUGAL pumps as water impelling apparatus, lend themselves especially to electrical transmission of power because of rotary movement, high speed of rotation, and almost complete immunity from derangement; also an efficiency, that, if facts are considered, exceeds that of other pumps that would substitute the centrifugal type. To these features can be added a lower first cost and maintenance. These last named features, arising principally out of the conditions of a continuous flow, bear an astonishing relation to reciprocating or piston pumps and is not more than one-fourth as much for a given volume of water; the cost of foundations is usually in the same proportion, so that for large volumes of water raised to moderate heights, there is scarcely comparison between the two systems of pumping. These being the advantages, I will now revert to some impediments that rise in the adaptation of centrifugal pumps to be driven by electric motors.

These impediments are: a constant duty, variable only within narrow limits, and a desired speed of rotation beyond what the hydraulic and constructive conditions permit. If there are other impediments that apply to centrifugal pumps I am not aware of them, and I will now proceed to show that even these can be removed.

---

[*] A paper read before the Second Annual Convention of the Pacific Coast Electric Transmission Association, held at San Francisco, Cal., Juue 21, 1898.

The first one, variable duty, when we come to consider it, is one that need not exist, because without even increasing the original cost, and with certain operative advantages, a pumping plant can be adapted to all practical requirements of a variable duty by subdivision into units.

In 1897 I prepared plans for pumping stations to be erected in New Orleans, by the Drainage Commission of that city, and as nearly all these pumps, requiring in the aggregate more than 10,000 horse power, were to be driven by electric motors, every phase of the subject came under consideration.

The heads varied from three to fourteen feet, and the volume included, besides seepage, the rainfall on about twenty-five square miles. The problem of electric transmission came up two years earlier, but would not, at first, be entertained by the Drainage Commission because of its novelty. Mr. Charles Brown, of Basel, Switzerland, who acted as my colleague in the preparation of plans for the hydraulic elements, strongly recommended the electrical method and submitted the conditions to Messrs. Brown, Bovrie & Co., of Baden, Germany, who, with Mr. Brown, Sr., made comparative estimates, including land areas, maintenance, fuel, water for condensing, the danger of fire, effect on insurance rates, cleanliness, and indeed all the various conditions, and decided that the circumstances were much in favor of electrical transmission.

The Drainage Commission, of which Major B. F. Harrod, U. S. A. Engineer Corps, is chief, came to the same conclusion in 1897, and then arose the subject of the variable duty which was an extreme, varying in a degree such as is never met with in other works of the kind; for example: twenty to one, or even more than this. But what at first seemed a formidable impediment entirely disappeared when we finally came to arrange the pumping stations. We simply divided them into units of 50 to 100 cubic feet per second, and found that the estimate was not increased, but was actually reduced by such subdivision.

I have taken some space to explain this matter, because the same conditions come up in nearly all cases when water is to be raised for irrigating purposes. The limits for economical subdivision are easily computed. If twenty cubic feet per second is to be raised, the cost of four pumps and motors, each of five cubic feet capacity, operating independently, will not be more than for one pump and motor of twenty cubic feet capacity, and when less than the maximum volume is pumped it must be remembered that conduit friction is almost eliminated by the low velocity of flow in the main pipes. When single pumps of small size are to be employed, throttling the discharge is perhaps the best means of regulation. The surplus water can be returned or circulated, but in either case the power consumed will be the same as for full duty, because the resistance of a throttling valve in either case must equal the discharge pressure. It is preferable to subdivide down to one or two cubic feet per second.

On the subject of pump design and speed of rotation, as already stated, the circumstances at New Orleans were extreme ones, and demanded a complete departure from common practice. The impellers in some cases, owing to the low heads, become smaller in diameter than the bore of the inlet pipes, and this led to the adoption of what I have named the "conoidal system" of construction, wherein the impellers are widened to any extent desired and still have a uniform and complete action at all points of these width.

To render this matter more clear I include with this paper a section and side view, also an elevation, of a pump on the conoidal system, arranged in accordance with the following quantities:

Capacity in cubic feet per minute	360
Head of water in feet	35
Revolutions per minute	1000
Efficiency (per cent. of power)	50 to 65
Horse power required, gross	40
Area of pipes, in inches	100
Approximate flow, feet per second	8

This, you will perceive, is an easy problem for a pump mode on the conoidal system, the impeller being in diameter as 13 to 9 of the bore of the suction pipes.

This form of construction, the subject of recent patents in this country, is not, as might be inferred, a simple widening of the pumps and reducing their diameters to permit a higher speed of rotation. The essential feature is the attainment at all points in the width of the impeller and uniform action and a change of the course of the water by easy curves, thus retaining all the efficiency possible in pumps of the regular construction.

This, as may be seen, disposes of the impediments of speed and permits in any case the employment of motors of economical adaptation; that is, of high rotative speed and small dimensions in proportion to their relative power.

I am not aware how far this system of conoidal impellers can be applied to very small pumps. Thus far designs have been made for pumps from 4 to 117 cubic feet per second, with pipes from 10 to 60 inches in diameter. I fully expect, however, that it will carry out, mechanically and economically, down to the smallest sizes, the general design being as shown in the present elevation. I may also state that it is the intention to adopt it in future practice for other than dredging and special pumps.

TO REDUCE GENERAL ELECTRIC SHARE CAPITAL.

THE directors of the General Electric Company have voted to recommend to the stockholders a reduction in the share capital of the Company, both common and preferred, of forty per cent., so that each holder of one hundred shares of present stock will get sixty shares of the new stock. This settlement, while satisfactory to the common stockholders, is regarded as particularly favorable to the preferred shareholders, inasmuch as it will render unnecessary the taking of any steps for the liquidation of the Company, in which event the preferred stockholders would receive only the same amount as the common stockholders, and no back dividends. The plan now adopted contemplates the payment, from the surplus earnings of the Company as they are hereafter made, of the accrued dividends on the preferred stock. On the basis of the new capitalization, $1,275,000 will be required annually to pay seven per cent. upon the preferred stock and six per cent. upon the common stock.

Proceedings of the Second Annual Convention of the Pacific Coast Electric Transmission Association, held at San Francisco, June 21st, 1898.

WHOEVER it was that "discovered" the world-famed Cliff House, at San Francisco, as a place for holding conventions, conferred a boon upon convention-going society, for a more admirable location could not have been selected than the one chosen for the holding of the second annual meeting of the Pacific Coast Electric Transmission Association on Tuesday, June 21st. The service and cuisene are excellent, the assembly room is luxuriously furnished for such occasions, and its site, with the mighty Pacific thundering at one's feet, is incomparably inspiring. Then the Cliff House, while in San Francisco, is sufficiently distant from the commercial centers to avoid interruptions of a business nature, and so it was that the executive session of the Association therein at 2:30 p. m., the open convention at 3 p. m., the dinner at 6 p. m., and the continuation of the open meeting at 8 o'clock, proved very profitable and highly enjoyable.

The members present at the executive session consisted of the following companies: Blue Lakes Water Company, represented by N. Randall Ellis; Central California Electric Company, by Dr. C. Van Norden; Sacramento Electric, Gas and Railway Company, by C. P. Gilbert; San Joaquin Electric Company, by J. S. Eastwood; Southern California Power Company, by O. H. Ensign; Standard Electric Company of California, by Wm. Angus; and the Yuba Power Company, by F. V. T. Lee. President C. P. Gilbert occupied the chair, with Robert McF. Doble as Secretary.

After the reading of the report of the secretary and treasurer, which showed the affairs of the Association to be in a thoroughly satisfactory and prosperous condition, the membership of the Association was increased by the election of the following:

Honorary member—F. A. C. Perrine, D. Sc., professor of electrical engineering, Leland Stanford Junior University, and electrical engineer-in-chief of the Standard Electric Company of California.

Member—Standard Electric Company of California.

Associate Members—A. E. Brooke Ridley, Pacific Coast agent Siemens-Halske Electric Company of America; S. N. Knight, President Knight Water Wheel Company; The Westinghouse Electric and Manufacturing Company; Edw. S. Cobb, of Cobb & Hesselmeyer, mechanical and hydraulic engineers; Pelton Water Wheel Company.

Officers for the ensuing term were then elected as follows:

President—Mr. W. Frank Pierce, President of the Blue Lakes Water Company.

Vice-President—Mr. Carroll N. Beal, Secretary and Treasurer of the Power Development Company.

Secretary—Mr. Geo. P. Low, editor and proprietor of The Journal of Electricity.

Treasurer—Mr. William Angus, Secretary of the Standard Electric Company of California.

The above officers, with Dr. C. Van Norden, President of the Central California Electric Company, constitute the Executive Committee for 1898-99.

At the conclusion of the executive meeting, the second annual convention of the Association was called to order in open meeting, those present being:

Angus, Wm., Standard Electric Company of California, San Francisco.
Babcock, A. H., Standard Electric Company of California, San Francisco.
Brown, Frank L., Washburn & Moen Manufacturing Company, San Francisco.
Burkholder, W. A., Westinghouse Electric and Manufacturing Company, San Francisco.
De Sabla, E. J., Jr., Nevada County Power Company, Nevada City, Cal.
Doble, Robert McF., Abner Doble Company, San Francisco.
Dutcher, C. E., Finance and Construction Company, San Francisco.
Eastwood, J. S., San Joaquin Electric Company, Fresno.
Ellis, N. Randall, Blue Lakes Water Company, San Francisco.
Ensign, O. H., Southern California Power Company, Redlands.
Gilbert, C. P., Sacramento Electric, Gas and Railway Company, Sacramento.
Hutton, C. W., Sacramento Electric, Gas and Railway Company, Sacramento.
Lacy, B. T., Parke & Lacy, San Francisco.
Lee, F. V. T., Yuba Power Company, San Francisco.
Lighthipe, J. A., General Electric Company, San Francisco.
Low, Geo. P., The Journal of Electricity.
Mooney, S. V., J. A. Roebling's Sons Company, San Francisco.
Ridley, A. E. Brooke, Siemens-Halske Electric Company, San Francisco.
Sedgwick, C. E., General Electric Company, San Francisco.
Sinclair, H. H. Southern California Power Company, Los Angeles.
Van Norden, Dr. C., Central California Electric Company, Sacramento.
Van Frank, E. M., Sutro Railway Company, San Francisco.
Walker, Geo. D., Washburn & Moen Manufacturing Company, San Francisco.
Warren, H. S., Blue Lakes Water Company, San Francisco.
Wybro, H. C., Walker Company, San Francisco.

A full report of the transactions of the convention appears below, President Gilbert opening with the following remarks:

The President: The meeting will now come to order in open session. Your President will spare you and the Convention from a President's address. Better material, I hope, has been provided, but a brief statement of the motives of this organization, and the progress made during the past year will, I hope, be in order.

The object of the Association is stated quite concisely in the by laws, and need not be repeated. It has for its precedent the National Electric Light Association and the Association of Edison Illuminating Companies, which have grown from small and somewhat uncertain beginnings, to be important features in the electrical industries in the East. Situated as the membership of this Association is, off the line of travel of eastern electrical interests, we are more dependent upon each other than they, and at the same time, being scattered over a coast line of over 1200 miles, association with each other is more difficult than among the electrical companies of the more thickly settled East.

This organization began with a pledged membership of ten, and has, during the year, increased to a total membership of fifteen, as it stands today. Sessions have been held at Santa Cruz, Sacramento, and San Francisco, it being part of the plan, as outlined at the organization, to hold quarterly sessions, visiting the different plants on the Coast. The papers read at these several meetings have, I believe, proved of great value to the members in bringing under discussion between representatives of operating companies, manufacturers and experts, electrical problems and experiences drawn from actual commercial practice, and I believe that all who have attended the meetings realize the possiblities of such an organization as this, in enabling operating managers, working in a new field, to avoid the mistakes made by others, as distinguished between the defects of design and defects of construction, and in the bringing into close touch the allied interests of operating plant manufacturer and expert. Such has been the aim of your officers, and such success has been attained as to justify the prediction that the Pacific Coast Electric Transmission Associatian can be made an important factor in the electrical industry of the Pacific Coast.

We will now call upon Mr. Low to read a paper written by Mr. Bly, who, unfortunately, is not here to read the paper for himself, and who has asked Mr. Low to read it for him.

Mr. Low reads the paper by Mr. Bly, appearing on page 5.

The President: Mr. Bly's paper has doubtless suggested many points of criticism. I ask Mr. Lighthipe for his opinion regarding the points on insulation there given, as some of them are, to my mind, perhaps a little novel, and no doubt Mr. Lighthipe will be able to call attention to other points.

OIL INSULATING VERSUS AIR COOLING.

Mr. Lighthipe: When we drop oil we adopt a new type of transformer that need not be kept enclosed—simply a type that we can drive air through. Our factory experiments have led us to abandon oil for high potentials, hence our experience is the opposite from the opinion expressed in the paper. We often find a certain amount of trouble in using oil, probably due to impurities, and it has been brought out by Professor Thompson, I think, that impurities in the oil will follow certain lines and gradually build a bridge of lower resistance than that of the rest of the oil, and while oil is a good thing to prevent puncture and to cover up punctures after they have been made, if we can do without it, we can build a type of transformer giving more room and more chance for cooling, and one that will give less trouble with the terminals coming out. My personal experience in oils, beyond the pressure of 2000 volts, is limited.

The President: I asked the question under the impression that the recommendation made in the paper was contrary to the practice of the General Electric Company in regard to oil insulation for high voltages. It has been my impression that the use of oil was one of the main dependents in using high voltages.

Mr. Lighthipe: The point was very well taken in regard to efficiency. As we run the high potential up, of course we have to make the air gap larger and larger, to protect ourselves, and as you increase the air gap you increase the C^2R losses on account of the extra copper, and at the same time run the efficiency down on account of the increased air gap in the magnetic line. So that I think the point is very well brought out that the transformer efficiency must not be the single thing to consider. If we want to raise our potentials, if we can change our loss on the line from ten per cent. to five per cent., we can just as well have one or two per cent. of it in the transformers, and build them safe and reliable. But I am not in position to debate on the question of oil at all. I don't know very much about oil. We are drifting away from oil.

Mr. Ensign: Regarding the use of oil in transformers, there are, no doubt, some advantages in its favor in the matter of size and weight, but it seems to me that when you come to fill up a case with oil, or with any substance where you cannot give thorough inspection to the transformer, you so submerge the insulating substance into the oil, that even if you could take it apart to examine it, you cannot get at the parts because they are smeared with something which you cannot find. It is quite easy sometimes to patch a transformer if you can locate the trouble, but with oil you cannot locate it, because oil, it always appeared to me, is over all the work. I had occasion to take apart a 250-light transformer, in which this point was brought out very plainly. All over the edges of the coil, and on the corners of the iron, was piled up a sediment. It was unaccountable how it got there. It did not look like dust. It had no grit to it, but it was a thin material, which was, considerable of it, supported in a buoyant state—held in the oil itself.

For myself, I saw some machines last summer that were given a high potential test, and so far as the matter of insulation is concerned, I believe it can be gotten quite as well without oil as with oil. One of these machines had a stationary armature of twenty coils, having an internal diameter somewhere in the neighborhood of twenty-four feet. It was insulated to stand for six minutes at a test of 30,000 volts. The higher or the greater the surface between the iron and the copper—the higher the condenser action which takes place—the higher the capacity, the more difficult it is to maintain those insulating properties. Those machines were built under such a guaranty as that, and they stood up to it. If they can do that with a large machine, and operate at 60,000 volts, it seems to me it can be accomplished in a transformer.

Dr. Van Norden: We have had considerable experience in the failure of high potential transformers, but we have received no light whatever, no explanation, unless that which has been given in the paper, that high efficiency has been sacrificed to insulation. We have had transformers that have broken down; but, very strange, there does not seem to be a jumping of the voltage across any distance, from one coil to another coil. As a rule, the individual coil breaks down, and the short circuiting is between the wires.

The President: Were those transformers oil transformers?

Dr. Van Norden: Yes, oil transformers, and as a rule, when we take them out we have no trouble whatever in taking them to pieces. We don't have the trouble the gentleman spoke of, of finding it impossible to discover the fault. Some times the fault is inside the coil entirely. Our conclusion is that it is some kind of a static phenomenon. The company which supplies the transformers seems to be unable to account for the facts. We thought for awhile that where there was a very great difference of voltage between two adjacent coils —there is a difference of about 7000 volts—we thought the current crossed that point, but we discovered that was a mistake, and if more than one coil was involved, it was because the thing went on too long, and in melting the copper, and so on, the other coil was affected, but that, originally, the trouble was inside of one coil. In one case it was the breaking down of the low potential side of a large raising transformer at the power house, where the voltage was between the two copper plates. There was not more than thirty volts difference in potential, and it arced across that. There seemed to be perfect insulation, and it melted these copper plates. Apparently the current jumped across from one plate to the other, and then the melting extended until perhaps five or six plates were affected. But why there should be the shortening across coils that had a difference of only fifteen to thirty volts potential, I could not understand, nor have I received from anyone any satisfactory explanation. It seems to be the opinion of those who are qualified to judge, that it was not a breaking down of the insulation, but some static phenomenon, the explanation of which is not forthcoming, so far. I want to say that for quite a while we have had no trouble with our transformers.

The President: I would inquire if Dr. Van Norden's experience has suggested any other in that line. Mr. Hutton, have we had any experience in connection with that which Dr. Van Norden has been taking up?

Mr. Hutton: There has been nothing like that; that is, from coil to coil. We had some insulating bushings where the high potential leads ran to the transformer. By dust accumulating on these, the current followed the dust and jumped across, setting the transformer on fire, but we have had nothing in the shape of jumping from coil to coil or layer to layer. The trouble with those bushings constitutes the only experience we have had of trouble with high potential transformers.

Dr. Van Norden: There seems to be an arcing with the high potential coils in some cases from one wire to the next. It begins inside the coil, and then continues from those two to the third, then to the fourth, and so passing right through the second coil, the wire melting as it proceeds. We have found the coils in various stages of this process. But ordinary insulation was on the wire, and there was almost no difference in potential between the wires.

Mr. Lighthipe: Considering this arcing from coil to coil, with a low potential of perhaps from thirty to one hundred volts, is it not possible that the fact that the oil was in there, and was not allowed to circulate, formed a bridge on the magnetic lines running across from coil to coil?

Dr. Van Norden: Oil could not get inside of the coils.

Mr. Lighthipe: Is not the coil immersed in the oil?

Dr. Van Norden: It is.

Mr. Lighthipe: The coil itself carries the oil in there, and the oil does not circulate.

Dr. Van Norden: Do you think the oil is between the wires inside of the coil?

Mr. Lighthipe: I think it is all through.

Dr. Van Norden: It is a cotton insulated wire, shellacked, then covered with muslin and shellacked, and then covered with paper. So I don't see how the oil could get between the wires.

Mr. Lighthipe: I think on taking them apart, you will find the oil completely inside. The point I was trying to bring out was that unless we have an oil that is chemically pure, which is almost an impossibility with the commercial oil used, we are liable to use oil with all sorts of foreign substances, and when we cannot keep the oil in constant circulation, the foreign matter in the oil will follow along certain lines of force and stay there and "bridge" across. In does not take much of a bridge to start an arc. Very little bridging will start the arc, even if there are only fifty volts between.

The point that Mr. Ensign brought out I think is very good. Where the transformer is get-at-able, you can clean it thoroughly with an air blast of thirty or forty pounds to the square inch. With oil you have simply got something—you don't know what—going on in there, and after it has broken down and been taken apart, the healing properties of the oil of covering up a rupture have probably covered up all traces of the trouble, and if we can get anything like equal results on high potentials without the use of oil, we have so many more advantages in the get-at-ability of the transformer, in watching it—and they do all need watching and keeping clean—that it seems to me that if it is possible to do without oil, and still get the high potentials, something is had that can be handled much better.

Dr. Van Norden: How would that bear upon the efficiency?

Mr. Lighthipe: I think the efficiency will be just as high. We all know that oil is good, better than air, but that air keeps the transformer cool, requiring no external device. We can blow air through as fast as we like, with a very small amount of energy, and there is nothing like a good draft of air to keep things cool. The main point about air transformers that I like is that they are not all buried up; they are accessible. It is like cable in the power house; no matter how well we insulate it, and put it down in conduits, we old people at the business don't like to see that wire buried, no matter how well it is buried. It can be buried in concrete or cement, or anything you like, but we always like to have it where we can get at it at any time. I would like to see every wire in buildings and power houses so placed that you can get at them if you have to.

Mr. Ensign: Regarding the matter of efficiency, so far as I can understand the transformer design, you can make the efficiency what you please if you put the proper bulk in it. If you have to allow air space, you make your transformer that much heavier, and get the same efficiency that you have when you have lowered the insulating space.

Mr. Lighthipe: Mr. Ensign is perfectly correct.

Mr. Lee: Our experience with the method of insulating and cooling transformers has led us to the conclusion that all different types have their proper use. Our company builds the self-cooling type, the air-cooled type, the oil-insulating self-cooling type, and the water-cooled, oil-insulated type. Taking the case of a small installation off the main line, where transformers are put in, it is usually out of the question to use the self-cooling type, because the size precludes it. If you cool with air you have to install a motor and fan, requiring some attention, whereas if you use the oil-insulated, water-cooled type, it is comparatively easy to have the water circulate, and but little water is necessary to absorb the heat. Where these transformers are used, they have a worm that encircles the transformer proper, and the water circulates through this worm. The oil surrounding this worm is kept at a uniform temperature, and the heat is dissipated. At the Yuba power house, just recently installed, we have the oil-insulated and water-cooled transformers, water for which is got trom a little reservoir put in for fire purposes.

So far as the difficulty in getting oil is concerned, what Mr. Lighthipe says is true—that is, to get oil that will stand a high test and be chemically pure. I suppose this is commercially impossible. At the same time you can get oil for transformers that will do the work. Another feature about an oil-insulated and water-jacketed transformer in large units, is that the cost is a great deal less, which is often important. We can build a transformer, oil-insulated and water-cooled, cheaper than we can one of the air-cooled type. They are possibly a little more weighty, but they are very compact and have little to look after. No question of dust arises, because they are water-tight and hermetically sealed. The leads, as rule, come out through porcelain, and they usually wax them up to keep out dirt. If, however, you have a large station containing many banks, it is comparatively easy to get a circulation of air; but at the Marysville sub-station, and the Brown's Valley sub-station, men are not there all the time, and it would be necessary to have a fan going to circulate the air for cooling them, whereas in these sub-stations they have a small tank of water filled only two or three times a week, which gives enough water to cool the transformers.

Mr. Eastwood: I have had some experience in the last few weeks in the transformer coils burning out. On coming from the mountains recently, I found we had lost one of our sub-station transformers. We put in an extra one and lost it also, and then we fixed up another one out of the two, and lost it. Yes, we have had some experience. I am happy to say, however, that we have made up a new one out of the wreck of the two we had left, and this transformer is still running.

A careful examination of our transformers, after running nearly three years, shows conclusively a point that has not been brought up, which is, that the insulations necessarily used in building transformers are perishable goods; that they have a limit of life the same as any other vegetable substance, and that when they are subject to the heat attending operations at a paying load, they are going to deteriorate very fast. Wherever there is a soldered electrical connection, the heat of twenty-four hour service will gradually cause a little of the solder to drop out, and every time you lose solder you are having a greater resistance between the parts of your connection, and the greater the resistance the greater the heat, and so on, until you come to the arcing point, when you get into serious trouble. We have found that it is necessary to go over the terminals of all our transformers and re-solder the connections.

The transformer coils that we have lost so far, have broken down between the parts of the coil, which primarily starts in an arc and short circuits. It is my opinion that these breakdowns occur largely from the heat and the deterioration of the insulating material. Rubber does not last but about one season. You can take a rubber band and put it around a lot of papers and lay them away for one summer, and the next summer you can pick it off in pieces. All the material that we use in insulation is liable to become carbonized and to crack, and to open up in various ways, and the constant accumulation of dust that we cannot avoid in this country will drop into the cracks and cause a short-circuit in the coil.

In the matter of the use of oil in transformers, we find that in putting oil into a set of small transformers that we call our "Chinatown" set, for some reason or other the water that had accumulated on top of the barrel while it stood in the yard, had gone down into the barrel, and when the oil was emptied into the transformer, strange as it may seem, the water went into the bottom of the transformer, and we had trouble. The transformer burned out, and in taking it down, we had the same experience that has been noted by Mr. Lighthipe and Mr. Ensign—we couldn't find the cause of the trouble without a great deal of cleaning off and hunting. The transformer oil that we get, even the best of it, is not, I think, pure enough to form a good insulator, so that now all our transformers are put up without oil.

GIVING TRANSFORMERS A REST.

Dr. Van Norden: Is it any advantage to let these transformers rest and not work them all the time? We are going to arrange our transformers so that they can be switched in or out, always having one or two to spare, and we intend to use the spare ones in place of some that are at rest. We have an idea that it is going to be to the advantage of the transformer and extend its life somewhat, not to be worked continuously. I should like to have some light upon that matter.

Mr. Lighthipe: Beyond the magnetizing current a transformer takes, the more load it has up to its capacity the better, and it will run that much cooler and that much easier. There is no ageing in the transformer that amounts to anything, if made of proper iron, and it might just as well be worked at half the capacity or one-fourth the capacity, as to let it rest. You will get a better transformer by running it below its load, and keeping the heat down, although you lose the magnetizing current and lose the extra number of units. I don't see where the economy is coming in. I would run them all light, I think.

Dr. Van Norden: You think it is better to run all those transformers and run them light?

Mr. Lighthipe: I would prefer to run them light. It is like a battery of boilers. It does not save a steam boiler by letting it rest, and it is better to run the boiler light than to let it stand idle. You would get a better economy in fuel, and you will not save the boiler by letting it rest idle. I think it is pretty near the same thing with a transformer. It will age just as rapidly without the current running through it.

The President: I would like to call on Mr. Eastwood for his experience in extending their lines and increasing their voltage. I am sure their experience will be quite interesting to the Association.

Mr. Eastwood: Mr. President, it is a little awkward position to be put in to comply with your request to say something about something that has not been done. Of course we lay it all to the Spaniards, on account of not being able to get the transformers from the General Electric Company, because their works were appropriated by Uncle Sam, who had to fight Spaniards. So you will see we are directly interested in the Spanish war. I will say, however, that we have our pole line finished, and our line is all strung up in the air there, waiting for current at the high tension voltage.

THE HANFORD EXTENSION.

Our intention is this: We have a transmission of thirty-five miles from our power house to Fresno, and we extended our line directly to Hanford from our Fresno sub-station, a distance of thirty-three miles further, and to raise the voltage from the power house, starting with an initial voltage of 19,500 from the power house, and delivering it at a voltage of 17,000 at Fresno, and at about 16,000 volts at the Hanford end. Our intention is to put in a new set of lightning arresters for handling this high tension voltage, and the object of it all is, aside from raising the voltage, to increase the capacity of the main line from the power house to Fresno without adding any more copper. By raising the voltage we increase our line capacity very considerably, and do away with the necessity of any more investment for some time.

Dr. Van Norden: Do you change your insulators?

Mr. Eastwood: We will change our insulators from the present porcelain to glass insulators. We have "Locke" glass insulators on the Hanford line throughout, and while we have not had a chance to try them yet, we feel satisfied that they are going to give us perfect success, for the reason that they have in other places.

Mr. Ensign: How does the size of the glass insulators compare with that of the porcelain?

Mr. Eastwood: Just about the same size as the porcelain that we are now using.

Mr. Lighthipe: You figure about three per cent. from Fresno to Hanford?

Mr. Eastwood: Yes. We have a single circuit line built from Fresno to Hanford, and, having had the experience of building our former line, we have tried to build a line that, under the conditions which exist, would be almost a model one. We have increased the distance between our poles by setting them 150 feet apart instead of 120, as we had before. The Hanford extension is all on the level plains, and is nearly absolutely straight. We put in a single circuit, three wires, placing one of the wires on top of the pole on a pin driven into a hole bored into the pole, the pole being hooped on top. The other two wires are carried on a short arm, and the distance between the wires is thirty inches between the top wire and the side wires, and thirty-two inches the other way across. We have almost an equilateral triangle of thirty inches. We are using the Locke glass insulator with the porcelain base and iron pins. In making angles and turns, and where the strain would come on the top of the pole, so as to be likely to split out the pin, we have put on a short cross arm on the side of the top of the pole, bolting it fast, and placing the wire around two insulators that we put on this short cross arm, giving two pins to pull against instead of one on top. The line is head-guyed at all turns, and thoroughly braced in every way. We feel that we have a line that will give us very little trouble. We are now sending a 1000-volt current over the line for the purpose of running a four horse-power motor for running a printing press in Hanford. We hope to have the installation completed some time this fall, just as soon as our transformers arrive. After that we will probably have some further experiences to relate with reference to the matter.

Dr. Van Norden: Will he tell us what is the character of the transformer that he uses in the sub-station at Hanford?

Mr. Eastwood: We will use the air-blast transformer at the sub-station at Hanford, and also the new ones we are putting in at the power-house and at the sub-station at Fresno; they are all General Electric transformers.

The President: Perhaps Mr. De Sabla can give us some experience from their lines. Something over a year ago Mr. De Sabla made some remarks similar to those which Mr. Eastwood has made.

Mr. De Sabla: We have only five thousand volts in our transmission, but like Mr. Eastwood, we are thinking some, with our experience still ahead of us, of increasing our voltage to fifteen thousand or sixteen thousand volts, as our business is increasing. But in all our line transmission we have had no trouble. We have had quite a little experience in transformers, however; rather a sad experience to start in with, but our trouble is now being overcome by the use of air-blast transformers which are giving good satisfaction, and also oil and water-cooled transformers, which are giving no trouble whatever.

The President: Has anyone had any experience with the water-cooling pipes in transformers becoming clogged?

Mr. Ensign: We have some water-cooled oil transformers and they have given excellent satisfaction. We have had repeated short circuits, and, at one time had what appeared to be a malicious short circuiting of the line. The transformers had all the kinetic energy of three 250 k. w. machines with large armatures, and wheels weighing in the neighborhood of eleven thousand pounds, turning six hundred revolutions a minute, thrown into them time and time again. They have never failed, but always stood up to their work, and have given first class satisfaction—run cool and all that—but we have once or twice gotten some muddy water in them, and there has been trouble to pay for the while. They will heat up right away, because all these water-cooled transformers are built very light. The coil and the core iron for a 100 k. w. transformer are comparatively very light, and one of the advantages in making water-cooled transformers is that they can be made much cheaper and lighter. I found they had a similar experience in Niagara Falls, where the water appears to be impregnated with lime, and the water-cooling coils became clogged with scale as in a boiler. They had a secondary transformer built, hollow, with water through it, and they couldn't get one-quarter of the water through it in six months that they could at first. When you have not plenty of extra transformers, or where, sometimes, your load is such that you cannot take them apart and put in a new one—and it is a very ticklish thing to do—it is very annoying. We had to turn the fire hose into our transformer to wash it out.

Mr. Sinclair: We have been operating 656 k. w. in water-cooled transformers on several systems about Redlands for about twenty months, and with the exception that Mr. Ensign states, we have had no trouble, though they have been running twenty-five per cent. overloaded all the time.

DUST IN AIR-COOLED TRANSFORMERS

Mr. Low: At the last meeting of the Association, we listened with a great deal of interest to a discussion on a paper by Dr. Perrine, in regard to the difficulties attending the gathering of dust on the back of marble switchboards. The ideas then expressed by Mr. Lighthipe have been demonstrated to be correct by the experience at the Yuba power house, where it was found that the unpolished marble would not stand above 34,000 volts, but would break down, whereas the polished surface offered no difficulty. Is it not possible, in air-cooled transformers, that there will be a precipitation of dust which may give rise to eventual short circuiting? What means are at hand for cleaning out the dust that will be precipitated? Filtering the air is not done, and it seems imperative to do so, more especially when extremely high potentials are used.

Mr. Lighthipe: I think Mr. Hutton's experience is due to dust in transformers. The high potentials enter through little wooden knobs and the dust collects there where it is very hard to reach. The dust collected along these knobs, and, after running several months, you would see little pin streaks, just as if somebody had taken a hot iron and made a mark across the wooden plugs. The short circuit Mr. Hutton speaks about, occurred from that one reason, and I think it occurrred before windows were in the power house, where heavy fog would probably collect on that dust, making a sort of mud, and the potential would creep across and cause the arc. We had to change the coils. It was entirely external; there was nothing the matter inside at all. I think the best cure for a transformer is to use a forty or fifty pound air blast; there is no other way. You can't dust them off, and I think all the modern transformer stations should be supplied with an air blast.

Mr. Low: Dust will certainly exercise an appreciable effect on transformers if it is allowed to get in, hence the advisability of filtering the air or hermetically sealing the transformer cases. I understand that at the Blue Lakes power house it has been found necessary to make a practice of cutting out a transformer at short intervals for the purpose of giving it a thorough cleaning. I have asked Mr. Doble to give some experience on that and perhaps he can do so.

Mr. Doble: I understand that the transformers that have recently been put in over at the South Eureka Mine have given considerable trouble, and I think probably Mr. Lee knows in regard to that. You remember, Mr. Lee, that those were the old flat type transformer.

Mr. Low: Was it from dust?

Mr. Doble: I am not sure.

Mr. Lee: The South Eureka transformer was a twenty horse power motor transformer and failed from the fact that while a twenty horse power motor was put in, they were taking equivalent to about thirty horse power in current. While they did not exactly burn out, they got hot enough for it to start, and we substituted for those the oil-insulated transformers. I have not heard anything about the necessity of getting the dust out, but I think it is quite possible. The power house is in a very dusty location, but the necessity of taking them apart to clean them is more in the way of preventing trouble.

The President: Are there any further questions in connection with the transformer?

Mr. Eastwood: In the matter of dust I might state that last winter I put into our sub-station a receiver and air compressor, and in using it for the first time we found that we could blow out large cakes of dust that had accumulated in the transformers, in the armatures of the arc machines and in the motors that drive them, and we have found that, as an auxiliary to running a station where we have motors and transformers, an air compressor plant is a very valuable one. Very often we would have a hot terminal on one of our transformers, and the station man would turn an air hose on the terminal and cool it. In that way we have been able to carry a very big load, and probably we might otherwise have had a breakdown. It is absolutely impossible to keep the dust out of the transformer; in the air blast type the dust in the air will fall in and be lodged against the different parts as it goes up through the transformer and will cake there and accumulate. If you have any moisture come into your statian, that will make mud.

Mr. Hutton: We have had an experience with dust on the back of high tension boards. The windows behind one of our high tension boards were left open, and, as the board had been set up for several months, some dust had accumulated on it. A fog came up that night and short circuited the back of the board. But in the case of a transformer and dust, it is an entirely different thing. On the back of a transmission board, all appliances are generally exposed, and the dust will make a clear track from one to the other. If moisture gets on the board you will have a leakage, while in transformers they are wound and covered with mica, so there is no chance for the dust to get on the wire itself at all. It appears to me that wherever you have anything in the shape of a conductor, where they are exposed to high potentials and dust happens on them, there is much more liability to have trouble there from dust than where it is covered up. I think it is a good thing to keep dust off, but I don't believe there is any particular trouble from dust in transformers, at least I have never seen anything of the kind during an experience of about three years. We use a little bellows and an ordinary duster to keep the transformers clean, and have never had any trouble from dust.

The President: Have we any further experience to draw on in this connection? As I understand this discussion, and the experiences given here, the evidence is rather in favor of the oil, water-cooled transformer. If I am wrong I beg to be corrected. As that was, to a certain extent contrary to Mr. Lighthipe's first remarks, perhaps it would be in order for him to show how far that comparison should be drawn, or that conclusion reached.

Mr. Lighthipe: I merely quote our company's experience. We have tried both, and have adopted the air blast as being preferable to the oil, in first cost, because it has been proven that we can build the oil, water-cooled, transformer cheaper than the air transformer, but we have decided that an air blast is preferable, and we are running the voltage up on the air type. Better results were obtained from air than oil, and cheapness does not cut any figure.

INSTANCES OF TRANSFORMER OVERLOADING.

Mr. Hutton: I can say one thing in favor of the air-cooled transformer. We put in three forty k. w. transformers, located halfway between Sacramento and Folsom. They operate a two thousand volt motor, and after we had started up, the belt began to slip, and ran off on one side, and jammed in between the brick wall and the pulley. In consequence, the motor began to slow down and the belt began to smoke, and the party in charge pulled out the switch, and there being an enormous current flowing, it arced across and made a short circuit. We had put in copper fuse on the transformer lines, which held quite a while before blowing out, but the load was enough to slow down two 750 k. w. generators.

The President: Are those oil transformers?

Mr. Hutton: No, air; natural draft.

Mr. Ensign: I had a similar experience represented in a load of 120 horse power at the Redlands power house. At the pumping house where there was something wrong with a centrifugal pump at the bottom of the shaft, forty feet beam. They were trying to force power enough into the pump to get the water down so that they could find out what the trouble was. We got there just as they finally got the water down, after having been pumped for five hours. The whole pump was hot and burst into smoke. The fluctuations at the power house showed that they were absorbing 120 h. p. delivered at the power house, and there was another motor running on the same transformer taking twenty-five h. p. There was 145 h. p. and the transformer never warmed up to any appreciable extent. They found the pump full of wedges that had been used in tunneling.

The Convention then adjourned until 8 p. m.

EVENING SESSION.

The evening session convened in the assembly room shortly after dinner, with Mr. H. H. Sinclair in the chair, in the absence of the president, Mr. W. Frank Pierce, and of the vice-president, Mr. C. N. Beal.

The Chair: We will now listen to a paper by Mr. John Richards, on "Centrifugal Pumps," to be read by Mr. Doble:

Mr. Doble: I might say for the information of those not present at the last meeting, that as the subject of "Centrifugal Pumps" had been brought up as a very important one in connection with electric transmission, we invited Mr. John Richards, who, as most of you know, is well versed in matters relating to centrifugal pumps, to prepare a paper. He was unable to do so at that time, but he sent a memorandum which I will read, because he refers to it in this present paper. That communication is as follows:

> The writer had the honor of an invitation to attend the February meeting of your Association in this city, and to contribute a paper or essay on the subject of adapting centrifugal pumps to be driven by electrical motors. Previous engagements prevented doing more at that time than to send in a brief memorandum relating to the subject. No copy of this paper was preserved, but as remembered it included a promise to at some future time present the matter in a more complete form. This I will now attempt to do in a compendious way with some illustrations of practice that will, no doubt, be of interest to the members.

The paper referred to in the communication just read was presented to the February meeting, but as it is brief, I will again read it. It is as follows:

I venture to contribute the following on the topic named in your note, which can, if you choose, be entered on your minutes.

The common opinion that centrifugal pumps require adaptation to a constant head is an error, except as to an inconsiderable loss in efficiency. This opinion arises out of its corrollary, namely: that centrifugal pumps have to operate at a constant, or nearly constant, velocity, which is true within narrow limits, being variable only in a slight degree by constructive features, such as the form of vanes.

These things being assumed, I need not say that centrifugal pumps lend themselves, with fair adaptation, to electrically transmitted power, under variable heads.

This matter will be made more clear from the following table which I employ in preparing designs for such pumps. It is not exact, but is near enough for practical working.

Head to produce the flow.	Flow in feet per minute.	Discharge in gallons per inch of area.
0.5	240	12
0.6	300	15
.75	360	20
1.0	480	25
2.0	600	31
2.5	720	37
4.0	900	46
7.0	1200	62

From the above table, it may be seen that a pump running at a constant number of revolutions, may operate at any head, and that variation of head produces corresponding change in flow and volume as in the second and third columns.

In respect to efficiency, this would, if discussed, involve certain intricate conditions, such as friction of the water, considered not only in respect to pipes and pump ducts, but also as the degrees of arc through which the water passes while in revolution. The losses by variation of head will therefore be, as you will perceive, not serious under a constant rate of revolution and variable heads.

Mr. Doble reads Mr. Richards' paper appearing on page 8.

The President: As this is a matter which is bound to be of great importance, for the pumping of water in the southern portion of the State for irrigation, and in the northern part of the State for other purposes, is a duty for electric motors that will increase very rapidly, it is a field which I find that we of the southern part of the State are very anxious to exploit properly, hence I would like to ask a very full discussion of this matter.

Mr. Lighthipe: A great proportion of the power of the Bakersfield plant is operating centrifugal pumps for irrigation purposes and I am disappointed that Mr. Beal is not here, because the Bakersfield plant has gone more fully into this matter than any other plant. The Sacramento company is branching out in this direction and we recently installed

PUMPING BY ELECTRICAL POWER.

something like a 150 h. p. irrigation plant outside of Sacramento. But, as Mr. Richards says, the operation of centrifugal pumps by electric power constitutes an ideal plant. It gives a rotating motion that operates a rotating blade in a centrifugal pump and the two fit together very compactly. I think there is a great field of development in this line.

Mr. Hutton: We have a plant that has been pumping sewerage for the city of Sacramento for the past year, and it has given no trouble. The last one we put in is used for irrigation purposes. It is a centrifugal pump, and the only trouble we have met so far has been an insignificant one with the pulley; otherwise it is giving good results. The gentleman who owns it, Mr. Stevens, seems to think that the matter of pumping is going to be quite an object with the farmers along the line there, between Sacramento and Folsom. The district there is very sandy, and in the dry season it does not hold the water very well, and irrigation is going to be a good thing. So I presume that if the experience with this present installation is satisfactory, which undoubtedly it will be from present indications, there will be quite a field for centrifugal pumps on our line. I think this one in particular is going to come out all right and work well.

Mr. Gilbert: In connection with the pump that Mr. Richards speaks of, his practical point, I think, is that the speed of the pump can be proportioned directly to that of the motor, securing a direct connection, which is one of the difficulties we have met. If Mr. Richards has contrived a pump that can be directly connected, I think he has made an important advance.

Mr. Lighthipe: Another important point about pumping is that it is a great thing to help out the load factor. Almost every consumer who pumps water for irrigation is willing to take electric power at a time when the lighting or other heavy load is not on. The time when water goes on to an orchard makes very little difference, and they can as well irrigate during the small hours of the morning, or when the load is very light. This will improve our load factor considerably.

The Chair: In regard to the load factor, the Redlands Company has about 120 to 150 h. p. in pumping motors, and all are connected on the basis Mr. Lightpipe suggests; that is, our contracts are made reserving the right to the company to cut off the supply of power to them between the hours of 6 and 10 in the summer time, or 5 and 9, as we may desire, according to the season of the year, and it has been working very satisfactorily indeed for something over a year. A pumping load of this nature is taken on at a time insuring the greatest profit to a water power plant. We have had some experience, mostly in small units, which has extended over some little time and been considerably varied, and I would like to call on Mr. Ensign to give such information as he has on this matter.

Mr. Ensign: We are operating a branch 10,000-volt line, seven miles long, extending northwest from Colton to three and a half miles northwest from San Bernardino, on which are three sets of two 20 k. w. natural draft transformers connected, each set furnishing current to two 20 h. p. induction motors, except one which has also one 10 h. p. motor, all driving centrifugal pumps. Centrifugal pumps lend themselves very readily to motor driving, and yet when using induction motors, which necessarily give a fixed speed, annoying difficulties sometimes arise. In the locality referred to, the source of water was originally flowing wells, until they began to pump them to increase the flow, when they all had to pump, and every pump added lowered the water, so the others found it necessary to speed up their pumps a little, or lower them deeper into the wells. Then if some pumps shut down, the water would raise and overload the other motors. So these people either keep on hand a supply of different pulleys to meet the varying demands on the pump, or mount the pump on a vertical movable carriage.

Each design of centrifugal pump will lift and force a certain distance at its highest efficiency at a certain speed. A change in any one of these conditions effects the efficiency. We have on that branch line a pump with a vertical shaft, which is the one that absorbed 100 h. p., due to wedges and other rubbish getting into it during the construction of the well. This pump is mounted on a vertical carriage, and more shafting is put on as the pump is lowered; but if the water carries much grit, whenever the pump shuts down the water rising in the well will be liable to ruin the bearings, as has been the experience with this pump. I am not myself in favor of centrifugal pumps in such a place with varying head of water, if I can find some other way of doing the work, but there are very many places where centrifugal pumps are undoubtedly the best. On the whole, this branch line has given a satisfactory water supply, and has given a good twenty-hour load for the power company.

There have also been two compressed air lifts installed on our system, which get more water from the well, but perhaps take a little more power for the same amount of water lifted; but on the other hand, they have less shut downs and repairs than the centrifugal pump. The air-lift consists of a compressor driven by motor with what appears to be a simple air pipe run down in the well, which, with its discharge pipe, can be raised or lowered to suit the height of the water. It is the most satisfactory method I have yet seen for raising water, though it is a very hard thing to get an accurate measurement of power on account of the fluctuations caused by the reciprocating motion. We have a large number of pumps connected to our system, and many more in prospect. A number are deep-well pumps; in one the pump cylinder is six feet long by nine inches in diameter and raises the water 120 feet, delivering about twenty miner's inches at an expenditure of 8 h. p.

Mr. Eastwood: Last winter we put in a small pump for the county orphanage, which consisted of a 3 h. p. motor, directly connected on the same plate with an inch and a half Crow centrifugal pump, and which is connected up with large section and two large discharges, one of which goes into a tank and the other is for an irrigation discharge lift about eight feet above the pump. The great difficulty in cases of this kind is to get a pump that will run at the speed of the motor. The 3 h. p. motor runs at a speed of 1,800, and to get a pump small enough to not overload the motor was quite a problem. In the construction of this pump the veins were extended, and separated by a very small notch from the next vein beyond, so allowing but a very small quantity of water to pass through the pump. With a lift of about sixty feet from a well that supplied an abundance of water, we had difficulty in keeping the motor from being overloaded. It took about 5 h. p. to work the pump as it was, so I put a check valve in the suction and cut the suction down, and in that way it gives excellent satisfaction. In addition, the Fresno Water Company is putting in a 50 h. p. centrifugal pump for use as a secondary pumping station. There we have a six-inch compound centrifugal pump which will be driven by a 50 h. p. induction motor belted. The lift is 110 feet, and the pump is arranged so that part of the lift is taken care of by one of the pumps, and another pump like it takes care of the other lift. I think this method has been well tried and has proved very satisfactory. I may add that for a couple of years we have been furnishing the city of Fresno with water pumped by an electric motor. We are running a triple-plunger pump having a capacity of four million gallons in twenty-four hours, with a 75 h. p. induction motor, belted and geared. It has given excellent satisfaction.

Mr. Lighthipe: Regarding deep plunger pumps, our experience shows that they throw a severe strain on the motor.

It is all load pulling up, and worse than no load going down. It is not noticed on a large plant, but on a small plant it dips the lights at every stroke. In the ice works at San Francisco we installed a plant in which most of the load was the motor to run a deep plunger pump. They wired in a few dozen lamps, but the volts were so irregular that the lamps could not be used at all. Being direct current, the easiest way around the trouble was to put a heavy series winding on the motor to make it accumulative, so that when a heavy load came on the motor slowed down. By putting in a good deal of wire on that series we equalized the voltage so one could scarcely see a wink on the lights.

Mr. Ensign: I think compressed air is better in deep wells. But when a motor drives a compressor there will be trouble with the current in a small plant, as even a small compressor will make a fluctuating on the lights part of the time. We had a breakdown in one of the cylinders of our big compound pump, and if all three plungers were running there were six points at which this pump was working. If you take out a few points, you get a gap, and the lights will be bobbing up and down all over town on account of the variation in the amount of current used. The needle in the ammeter will be bobbing back and forth, and you will have the same thing all over the system. The air-compressor will do the same thing exactly, as it gives an oscillating motion. We ought to apply a constant power, and I don't how it can be done any better than with a centrifugal pump.

The Chair: As the operation of that pump caused a flickering in the lights, I would like to ask what proportion the pump bears to the total load?

Mr. Ensign: It is a very small proportion, because it only takes 60 h. p. to run it. It makes fluctuation and perceptible flickering.

Mr. Lighthipe: I think the point to aim at in any mechanical device operated by electric motors is to get a rotary motion,—to avoid the reciprocating motion as far as possible in every case, even on air compressors. It is not the work that the plunger does so much as it is this large column of water that has to be accelerated. It is acceleration that cuts the figure, and we should encourage the improvement of the rotary pump, or anything rotary that goes on electric work. We want to get rid of the reciprocating motions, if possible, and the more steady tongue we have on motors the more steady the load will be, and the more encouragement we can give to the improvement of centrifugal pumps the better we are off in the service we can give.

The Chair: While that would seem on its face to be so, yet our experience does not seem, necessarily, to bear that out. We have an ice plant operating at Redlands, and Mr. Ensign can tell you the effect of that double-cylinder compressor, when only one side is running, and when the load on that is a very large proportion of the actual load.

(Proceedings of the evening session of the Pacific Coast Electric Transmission Association will be concluded in the August number of The Journal of Electricity.)

TO PREVENT LINE LEAKAGE.

On June 7th letters patent were granted to Fred M. Locke, of Victor, N. Y., on an improved high tension insulator, by the design of which it is proposed to prevent leakage of the current from the wire over the insulator to the supporting pin, thereby obviating the burning off of the pin. This Mr. Locke accomplishes by so elongating the inner petticoat of the insulator that it will closely cover or enclose the supporting pin down to a point adjacent to the cross arm, and in addition this inner elongated petticoat is made smaller in diameter in proportion to the petticoats of the insulator above it.

The burning off of pins where high voltage currents are transmitted has rendered necessary some means of preventing this leakage, and Mr. Locke claims that this can be accomplished by the extension of the inner petticoat in the manner described, thus providing a protecting sleeve for the pin and increasing the arcing distance of the current around the insulator.

Mr. Locke desires the announcement made that parties buying such insulators from the R. Thomas Sons Company will be asked to pay royalties on the same.

Fraternal

THE PACIFIC COAST GAS ASSOCIATION.

Mr. John A. Britton, secretary of the Pacific Coast Gas Association, has issued the following official notice of the coming annual meeting of the Association, to be held in San Francisco during the present month:

The sixth annual convention of the Pacific Coast Gas Association, Mr. F. H. Eichbaum, President, will be held in San Francisco, on Tuesday and Wednesday, July 19 and 20, 1898, in the office of the building of the San Francisco Gas and Electric Company; morning sessions, from 10:15 to 12:30; afternoon sessions, 2 to 4:30. The Board of Directors will meet on Monday, July 18, at 8 p. m., at headquarters, which are hereby established at the office of Mr. E. C. Jones, chief engineer of the San Francisco Gas and Electric Company, No. 415 Post street.

Copies of all papers, questions, and applications for membership, must be mailed to the secretary prior to July 18. Members to whom questions are assigned are requested to send answers promptly.

Papers will be submitted by the following members on subjects to be announced: E. C. Jones, C. O. Poole, John L. Howard and F. Foveaux, of San Francisco; O. M. Gregory, San Jose, Cal.; John A. Britton, Oakland, Cal.; W. M. Parker, Bellingham Bay, Wash.; A. Gutsch, Fresno, Cal. In addition to his address as president, Mr. Eichbaum will continue his "Reminiscences." Mr. George H. Hollidge of Merced, Cal. has charge of "Wrinkles," and Mr. John Clement of Red Bluff, Cal., is directing the "Experiences." It is hoped that the members will contribute liberally to both these departments.

An excursion is arranged for Thursday, July 21, particulars of which will be hereafter announced.

The Secretary has on hand a number of bound copies of the "Proceedings," which are purchasable at $2.00 per copy.

Mr. E. H. Forst has been appointed manager of the consolidated interests of the Pacific Coast Electric Company and the California Electrical Supply and Construction Company, now known under the name of the former concern and located at 1145 Market street, San Francisco.

Mr. M. I. Sipe, late a foreman of the San Francisco office of the General Electric Company, has been made Superintendent of Construction for the Washington Water Power Company of Spokane, Wash.

Prof. C. L. Cory, of the Department of Electrical Engineering, University of California, is spending the summer vacation in making a tour of the principal electrical plants in the Pacific Northwest.

Mr. E. C. Sharp, late of Los Angeles, has been appointed manager of sales for the Pacific Arc Lamp Company of San Francisco, which will hereafter occupy his entire attention.

Mr. Ira G. Francis, City Electrician of Los Angeles, was in San Francisco last week.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of
Electricity, Gas, and Power.

Official Organ of the Pacific Coast Electric Transmission Association.

Subscription invariably payable in advance. Terms—Domestic, One Dollar per Year; Foreign, Two Dollars per Year. The trade supplied by the San Francisco News Company. Advertising rates furnished on application

GEO. P. LOW, : : : Editor and Proprietor

PUBLICATION OFFICE:
320 CALIFORNIA STREET,
ROOM 14.

Address all communications to
Editorial rooms, 427 TENTH AVE.
Telephone, "Steiner 623."

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME VI. JULY, 1898 NUMBER 1

EDITORIAL.

EFFICIENCIES, ACTUAL AND THEORETICAL.

The vaunted accuracy of scientific, or rather engineering determinations is delusive in many problems wherein exact results as to efficiencies are to be predetermined. Witness, for instance, the earnestness and unity of purpose with which the greatest governments of the world are endeavoring to design ships of war that will attain the highest possible speed under prescribed conditions. What is the "highest possible speed?" No one knows. The very best of engineering skill is engaged; every facility that money can buy or human ingenuity can devise is afforded without stint to aid in securing perfection in model and design; the experience and wisdom of the world's greatest shipbuilders add refinements to the work of the designers, and yet, who of all these can definitely announce the speed of the ship prior to the momentous day of her trial trip. A vessel may be designed for a given speed which, under proper conditions as to steaming, engines, model and bottom, may be made or even exceeded, but the speed which it is designed to make and the speed which it will actually make will not, it is safe to say, be identical. The one is theoretical, the other practical; and theory and practice are seldom, if ever, in entire consonance.

Though the instance cited is an extreme case, because of the many attendant conditions which exert important influences in the final result, it is by no means without parallel in engineering work. Equally impossible is it to determine beforehand the electrostatic capacity of a long distance, high voltage transmission line because of the varying influences of the power factor, atmospheric conditions and line separation; or to accurately estimate the over-all efficiency of a transmission plant because of undeterminable factors, among which are the co-efficient of friction of the pipe line and the changes in efficiency in water wheels, generators, transformers and line with each change in load; or, more simple yet, apparently, to accurately determine the mechanical horse-power that will be derived from a stream of water of given size and head, is impossible until the actual trial is made.

It is a consideration of such matters as these that brings out most strongly the differences which invariably exist between the theoretical and the practical—and practical is but another word for "real" and "effective." A mountain stream may be torrential during certain seasons, during which its energy may be reckoned with entire propriety in thousands of horse-power, but at the end of the summer the stream may be but a rivulet incapable of doing work of any commercial utility as a source of water power. This would reduce the effective value of the water right to practically *nil*, for, as a chain is no stronger than its weakest link, a water power ordinarily finds its limit of commercial availability in its minimum flow. Conservation will secure an equalization of the minimum and maximum flow, thereby increasing the value of the water power, but introducing counter issues such as seepage and evaporation, which still further render it impossible to determine before the works are installed and tested, just what the exact plant efficiency will finally be. Moreover, no two tests of a plant, whether of an electric or hydraulic nature, will show exactly uniform results and a failure to properly appreciate the many uncertain and indeterminate factors entering into considerations involving difference between theoretical and effective results, may be ascribed as a cause of the major portion of the misfortunes that have overtaken enterprises which have, sooner or later, been reduced to unsatisfactory, unprofitable and chaotic conditions.

EUROPEAN INDUSTRIAL CONDITIONS.

The industrial situation in Europe is a theme that, prior to the outbreak of the Hispano-American war, was productive of much discussion in both the lay and technical press, but the exigencies of war have so crowded the columns of the press that the American public is overlooking the unfavorable conditions of trade which the vigorous protective policy of the present administration is heaping upon European countries to the almost incalculable benefit of our own industries. The seriousness of this situation is strongly set forth in the accompanying letter received from Professor A. Van der Naillen, President of the Van der Naillen School of Engineering of San Francisco, who indicates, as well, some of the advantages that are bound to accrue to American engineering interests from a continuation of the present national policy. Professor Van der Naillen is so well and favorably known that his letter cannot but be accepted as a truthful exposition of the existing European situation, as well as a sage forecast of the probable influences which it will exert on American engineering trades.

Writing from Liege, Belgium, under date of June 19th Professor Van der Naillen says:

> You have no idea what engineering opportunities are going to arise for those of the coming generation who will study and make themselves proficient in their chosen professions. These European countries are being steadfastly ruined by the protective policy of

President McKinley. The industries here are not paying dividends, while many manufacturers are running at a loss and all have an eye turned toward America, whither they hope to take their entire industrial plants or close up their factories here and invest their capital in the United States. Moreover. I have recently witnessed the elections here and the Socialists and Anarchists have made great gains. Many incipient revolutions have had to be suppressed and the industries feel nervous and capital unsafe. Worse than this, the universal revolution is feared in the not-far distant future, so that all eyes are turned toward America as the the only country worth while to live in and the only country offering to capital, intelligently invested, many chances of development and increase, and then the services of engineers, electricians, mechanics, draughtsmen, surveyors, assayers and all similar professions, will be more and more in demand. The mining engineers of Europe confine their studies mostly to coal and iron mining and possess but a skimming of knowledge of the precious metals, so that the skill of the California mining engineer will at least always be required. The science of electricity, too, is bound to be of more importance than ever, and I am just commencing a thorough investigation of the school of electrical engineering established here in Liege and founded by Montefiore Levy. It is really the only school teaching the electrical science exclusively, and it is reported to be the best and most complete in theoretical instruction, but for the practical application of these theories, the credit is given to America. We shall soon see how long America has only this credit.

PETROLEUM IN SOUTHERN CALIFORNIA.

According to the State Mining Bureau the production of petroleum in Southern California for 1897 amounted to nearly 2,000,000 barrels, of which 1,339,011 barrels were produced in Los Angeles county, 368,228 barrels in Ventura county, 130,136 barrels in Santa Barbara county, about 70,000 barrels in Fresno county, and about 50,000 barrels in Santa Clara county. This shows an increase of about 750,000 barrels over the production for 1896, but nevertheless the wells in the Eastern field within Los Angeles are beginning to fall off in production and oil men are looking around for new fields to conquer.

It has now been so long since oil was "struck" in Southern California that if it were going to be found in sufficient quantities to bring about cheap fuel, its influences in this direction would certainly have been appreciated long ago. It is reported that the greater portion of the oil produced in and about Los Angeles is used in the locomotives of the Santa Fe system on that division. At all events, there is no longer a doubt but that electrical transmission interests in California have nothing to fear from the era of cheap fuel that, it was said, would result from the oil of the Los Angeles fields.

A NEW DRESS.

THE fact is self-evident that the beginning of Volume VI of THE JOURNAL OF ELECTRICITY is marked by several departures from the typographical style which has been characteristic of it almost since the dawn of its existence. The general proportions remain the same, but among the typographical changes will be noted a little more display, and the appearance of a greater amount of reading matter because of the extended use of smaller type. It is believed that these changes are for the better—but of this let critics speak.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

COST OF PRODUCING ELECTRICITY.

Mr. Robert Hammond recently contributed a paper to the British Institution of Electrical Engineers upon the cost of generating and distributing electrical energy, taking as a basis of his computations the yearly statements filed by the electricity supply works under the electric lighting act of 1882. Naturally a wide diversity of results is given, but the returns expressing most closely the existing conditions show that the total cost per kilowatt-hour ranges from 1.13d. to 6.04d, while nine of the leading electricity works produced electricity for less than 2d. per kilowatt-hour during 1896-97. The paper, moreover, sets forth that the conditions which make these low costs possible are due to: (1). Heavy output, as is shown by diagrams proving that the costs fall rapidly as the output increases; (2), Load factor, or the ratio of the actual units generated to the product of the maximum of the year and the total hours of the year; (3) A thoroughly reliable generating and distributing plant, adequately tested; (4) The "engineer factor," as is brought out from the fact that in every one of the plants where low costs prevail, the engineer in charge is distinguished for his competence and assiduity, and (5) all-round efficiency in the generating and distributing plant.

The paper, which is illustrated with diagrams based on data secured as stated, is in reality a succinct embodiment of the performance of English central stations in the matter of the cost of producing electrical energy therefrom and the suggestions it contains are worthy of most mature consideration.

* * *

A NOTEWORTHY AND STRIKING ARTICLE.

The *San Francisco Call* gives the following editorial notice concerning the Yuba-Marysville transmission described in the May issue:

> The current number of THE JOURNAL OF ELECTRICITY gives the place of honor in its pages to an elaborate description, richly illustrated, of the electric power transmission system recently established by the Yuba Power Company at Marysville. The article is a noteworthy one, and presents in a striking way one of the most important of the accomplishments of Californian enterprise.
>
> It is noted that just 125 days elapsed from the date when the power company began work on the system until it was placed in operation. The work achieved during that comparatively short time included the entire rebuilding of thirty odd miles of water system, the location of the power-house, the erection of the pole line with two sub-stations, the city distribution of over 5000 lights, and the installation of all the hydraulic and electrical equipments of the plant. With this record the company holds the well merited distinction of having made the quickest installation of that magnitude ever accomplished.
>
> The plant, moreover, is as notable for its excellence as for the speed with which it was built. Rapidly as the work was performed, thoroughness and quality were never subordinated for the sake of gaining time. The system stands, therefore, as one of the best illustrations in the world of what American science and engineering skill can do in the way of providing for the transmission of electrical energy.
>
> The example set in this case, will, of course, be followed elsewhere. The topography of California is well adapted for such enterprises, and the date can hardly be far distant when

nearly every city of note in the State will have power furnished it on lines similar to that which is now proving such a benefit to Marysville.

ELECTIC PROPERTIES OF GLASS.

Now that glass insulators are rapidly coming into popularity for the support of transmission lines, any information concerning the electric properties of glass is of value. Messrs. Andrew Gray and J. J. Dobbie have given to the Royal Society a report of the first installment of work undertaken with a view to finally determining, if possible, the circumstances which affect the conductivity and specific inductive capacity of glass, from which it appears that potash and soda lime glasses have a higher conductivity than flint glass. The electric conductivity of glass falls off almost regularly as the amount of lead oxide increases, while it rises with the amount of soda, and the glass which possessed the highest specific resistance—$8{,}400 \times 10^{10}$ ohms—contained 40.5 per cent. of lead oxide, 7.5 per cent. of potassium oxide, and 2.1 per cent. of sodium oxide. Both of the lead glasses dealt with contained a still higher percentage of lead oxide and were almost free from soda, and the electrical resistance was so great as not to be measureable. It is impossible to say how far this result is due to the increase of lead oxide, and how far to the elimination of soda—a point which can only be decided by preparing a lead glass in which the potash is replaced as nearly as possible by the equivalent amount of soda. It is noteworthy that a glass whose chemical composition may be expressed by a simple chemical formula invariably has a high resistance.

ELECTRIC MOTORS IN THE STABLE.

THE electric motor has become a necessary adjunct to every well appointed modern stable, whether livery or private, and horses are now groomed and clipped by electricity, with neatness and dispatch.

The advantages of the application of the electric motor to grooming and clipping machines, were early realized by an eastern shearer company and its efforts toward supplying a demand for electrically driven groomers and clippers has met with considerable success. Hitherto, however, it has supplied merely the machinery exclusive of the motor, but owing to a demand which has arisen for complete grooming and clipping installations, it is now supplying the motor as well. In doing this, however, it has found it necessary to simplify in a large measure the driving mechanism.

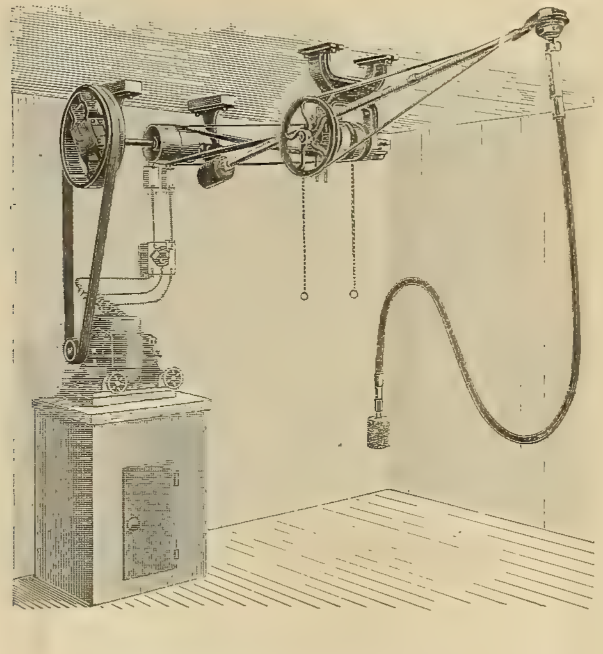


FIG. 1—OLD METHOD OF DRIVE THROUGH DOUBLE COUNTERSHAFING.

The first of the accompanying illustrations shows a grooming and clipping machine driven by a bipolar motor through double countershafting with conical and idle pulleys. This method, while it allows of the operation of two or more groomers and clippers from one motor, was not satisfactory on account of the complication of belts and pulleys necessary, and when it became a question of furnishing both operating and driving machinery, it was felt that some more direct method of drive was needed. This was found in the small power, moderate speed motors developed by the General Electric Company, which in addition to its line of small power induction motors has also recently perfected a line of direct current small power motors known as the "C. A." type. These motors may be run in any position either attached to the wall, set on a bracket or hung from the ceiling, and have been found peculiarly adapted to drive groomers and clippers.

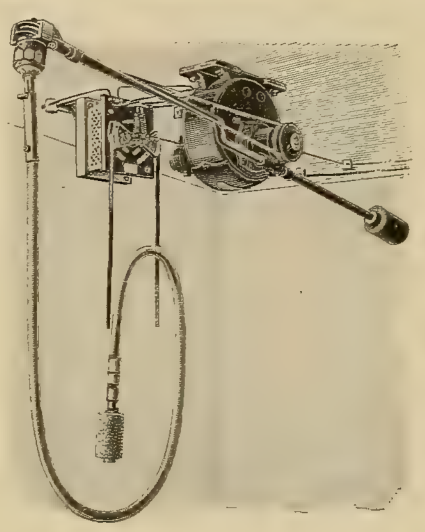


FIG. 2—NEW METHOD OF DIRECT DRIVE WITH "C. A." MOTOR.

The second illustration shows a more recent machine complete with a one h. p. "C. A." motor and automatic starting rheostat. In this case no floor space is occupied by the motor, the counter-shafting is eliminated, and the belting is reduced to a single belt from the motor pulley to the pulley attached to the flexible shaft of the groomer and clipper. The motor is fastened to the ceiling beams in an inverted position and the counterpoise, or balance arm, is attached to a swivel on the motor case. The automatic starting box, also fastened to the ceiling, is of the reversing type, with the contact arms pulled in either direction by leather straps. This clipping and grooming outfit is singularly compact and simple and requires almost no attention beyond an occasional oiling. In ordering, it is simply necessary to state the nature and voltage of the current, and, if alternating, the phase and number of alternations.

With the electric motor-driven groomer and clipper, a horse may be thoroughly brushed in about two and a-half minutes and clipped in about thirty-five minutes.

Electro-Therapeuty

ANAESTHESIA ELECTRICALLY INDUCED.

While making experiments on the sensations derived from sinusoidal currents, it was recently discovered by Prof. Scripture, of Yale, that anæsthesia of the tissues resulted from currents of high frequency, the condition even persisting for some time after the removal of the electrodes. This should excite the attention of medical men, surgeons more especially; and if such local anæsthesia proves to be wholly practicable and safe, it will prove a veritable boon.—Scientific American.

Personal

MR. JAMES ALFRED LIGHTHIPE, an excellent likeness of whom appears on this page, holds the enviable distinction of being universally more popular and esteemed than any other electrical engineer on the Pacific Coast. He is, above all others, the one man in the profession who can rest secure in the knowledge that despite his very active service in electro-technical matters, he has administered his high offices so fairly, so honestly, so impartially and so competently that he is respected, admired and even beloved by all.

The best engineers, like true poets, are born, not made, and as the professional rating of Mr. Lighthipe is of the best, his engineering career forms no exception to the general rule. So it transpired that while quite a young man, Mr. Lighthipe found student life less congenial than active work and accordingly he left the Stevens Institute of Technology, at Hoboken, N. J., before finishing his course and became an assistant of Mr. T. A. Edison at the little laboratory at Menlo—the institution that will always stand in electrical history as the birthplace of Edison's greatest inventions. About this time, 1879, the phonograph, the Edison telephone, and the host of other Edisonian inventions, were under development or being introduced. In those pioneering days, men of some experience, of sound judgment and, more than all, of great intellectual resources, were in demand, and Mr. Lighthipe was chosen as one of the corps to go to London where, under the active management of Mr. E. H. Johnson, they "set up" the first "chalk telephone" installation in a foreign country. The brief period that Mr. Lighthipe spent with Edison at Menlo Park was during the hard working period before fame and fortune had favored the great inventor. The period was one of never ending interest, hence a single anecdote may be permitted:

In a portion of the laboratory away from all work-a-day (and-night) devices was a small pipe organ that occasionally gave solace to Edison. When distraught with a brain-racking problem and after long hours of labor, he would sit himself at that organ and play and sing in quest of relaxation. But in play, as in work, the enormous energy of the man was beyond comparison. He would play and sing, as the vernacular of to-day goes, "to beat the band," until, unmindful of the rate at which his feet were pumping, a wheeze and rapid dying out of the chords would tell that he had burst the bellows again. Then he would say: "Lighthipe, better patch it up again so I can finish my tune," which Lighthipe did, and so often repeated that the bellows became a prominent specimen of the none-such family from the sheep skin patchings on it.

JAMES ALFRED LIGHTHIPE.

It was in the summer of 1880 that Mr. Lighthipe was sent from London to Antwerp where, under the late Mr. Gardiner G. Hubbard, he was installing engineer for the International Bell Telephone Co. The two years following were spent in supervising the erection of the telephone exchange system of Antwerp and Verviers, Belgium, both using Blake transmitters and Bell receivers. At the completion of this work Mr. Lighthipe returned to London where he remained for six months as superintendent of the British Insulite Company. The rapidly growing importance of the Edison system, including dynamos, incandescent lamps and all accessory equipments, made it advisable to start factories for their manufacture on a large scale in the principal continental capitals, and accordingly Mr. Lighthipe was sent to Paris where, under the management of Mr. Chas. Batchelor, he entered the factories of the Societe Industrial and Commercial d'Edison, at Ivry. Nikola Tesla was also at the same factory at Ivry, prior to his coming to America. After about one year's service in Paris, Mr. Lighthipe was transferred to Berlin, where he held a similar position with the Deutsche Edison Gesellschaft. A year later he returned to New York where he remained as engineer for the Brush-Swan Company for nine months, after which he started in business for himself in Philadelphia, Pa. Twelve months in commercial life convinced Mr. Lighthipe that engineering proper was more suited to his taste than mercantile pursuits and so he returned to active electrical work at Wilmington, Del., as chief electrician of the Wilmington City Electric Company. Mr. W. S. Heger, now manager of the Pacific Coast office of the Westinghouse Electric and Manufacturing Co., was then Edison agent for Delaware, Maryland, Virginia and North Carolina. When Mr. Heger resigned that position to take the Pacific Coast office of the United Edison Manufacturing Company, Mr. Lighthipe accompanied him, arriving in San Francisco on January, 1, 1890, and was at once made superintendent of construction. When the various Edison interests were reorganized into one concern—the Edison General Electric Company—Mr. Lighthipe was retained as District Engineer for the Pacific Coast, and later, when the Edison General Electric Company consolidated with the Thomson-Houston Electric Company as the General Electric Company, Mr. Lighthipe was advanced to his present position of Chief Engineer for the Pacific Coast district at San Francisco. Mr. Lighthipe's absolute honesty of opinion and purpose, and this trait, perhaps more than any other, has won for him the deserved popularity of which he might so well be proud.

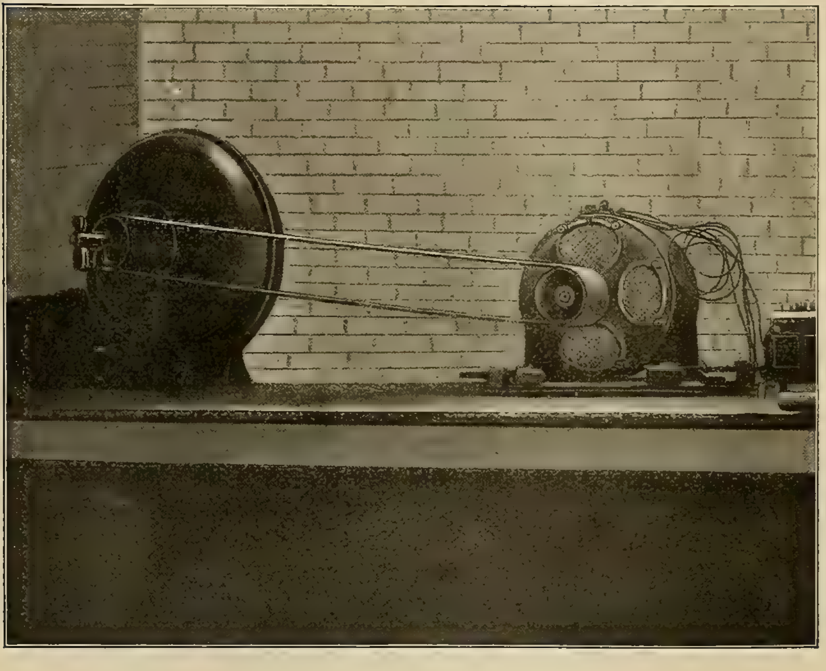
Mining

ELECTRICITY IN MINING.—III.

LIGHTING OF MINES.

SCIENCE had made a great step when Sir Humphrey Davy called to his assistant to come and see the effect of a gauze shield on an adjacent flame, and from that phenomenon developed his safety lamp; but science has made a long step in advance of even that day in the evolution of modern methods for facilitating the work of mining.

Among these advances, none has been more striking than that of mine illumination. The question is again one of economy, modified by considerations of safety. The problem of electric lighting is one that is of some complexity, yet without any uncertain factors. From the coal pile to the incandescent filament in the vacuum bulb, through boiler and engine, dynamo, line, transformer, house wires, and finally into the glowing source of light, is a long series of transformations. With the average apparatus of this kind, the proportion of actual energy in the coal that is utilized in light, is only about one-sixth of one per cent., yet nature is so rich that she overlooks the waste and gives ample return to the human race even under such conditions.



BELTED ELECTRIC FAN FOR MINES.

Where a source of water power is available for lighting purposes, the efficiency of a lighting system is increased in a truly marvelous degree. The two most efficient, practical machines known to engineering science, are, without doubt, the electric dynamo and the turbine water wheel. The efficiency of the former runs above 95 per cent.; that of the latter has been found to be as high as 97 per cent., and in practice is probably above 93 per cent. Assuming the values 95 per cent. and 93 per cent. for the respective efficiencies, the comparative economy of the steam driven and water plants may be readily shown, as follows:

The ordinary standard of economy is the "watt-hours per pound of coal." Assume the heating value of a pound of good coal to be 12,000 thermal units, which is equivalent to 9,336,000 foot-pounds of energy. An average central station economy is probably about 100 watt-hours per pound of such coal. One watt is equivalent to $\frac{1}{746}$ of a horse power; that is, to 44.2 foot-pounds per minute, or 2,652 foot-pounds in one hour. One hundred watt-hours per pound of coal would then represent 265,200 foot-pounds of energy produced from 9,336,000 foot-pounds—an efficiency of .0284. With a turbine of 93 per cent. efficiency, and a dynamo of 95 per cent., the combined efficiency is 88 per cent., which is over thirty times that just calculated.

The "watt-hours per pound of coal" equivalent to the efficiency of 88 per cent. is 3,098. The very best modern central station operated by steam power, rarely brings this figure above 200. Comparison is unnecessary. These are not wild, hypothetical fancies, but the efficiencies here stated are being daily attained in practice. Under such conditions the cost of electric current for lighting is less than one-fiftieth of a cent per lamp-hour (16 c. p.). This is cheaper than tallow.

Electric lighting in mines is by far the simplest and safest method of illumination. All switches and points of contact are encased in spark proof covers, making it impossible for the formation of a temporary arc during the breaking of the circuit to cause an explosion, in locations where such an event might otherwise be a possibility. The rules which the National Board of Underwriters have established for house wiring are, in certain respects, applicable to the conditions of mine service; and, in those respects, they should be observed. The ordinary voltage of incandescent lamps operated in parallel, is either 50 or 100. For the long distances covered by the requirements of most mines, the loss would be very large at these voltages. The system has therefore been adopted of connecting lamps in series clusters across mains of a sufficiently high voltage for reasonable economy. Thus five 50 volt lamps are connected in series across a 250 volt circuit, or five 100 volt lamps across a 500 volt circuit. On many street railways, the cars are lighted by ten 50 volt lamps in series with the line and the track, the difference of potential being here from 500 to 550, or about fifty volts per lamp. Another system is that of "series incandescent lighting," properly so called, in which lamps of especial design are operated on a series, constant current circuit, direct current being used. To supply direct current for this purpose from the polyphase current transmitted from the generators, a machine called a rotary transformer is utilized. This apparatus is practically a motor mounted on the same shaft with a generator. The alternating polyphase current from the main line runs the motor, which in turn runs a generator, the latter supplying direct current. The Westinghouse rotaries are standard apparatus of high efficiency. They are simple in construction and operation, and are in use to a very large extent for such purposes as that mentioned.

An objection to the method of lighting just mentioned, is the high voltage of the line necessary. One hundred 25 candle power lamps on a circuit of moderate length, may require a potential of 1000 volts, and the consequences of an accidental "ground" on such a circuit are apt to be very serious to the victim.

For lighting large open spaces, and in fact for any purpose where a light of intensity is required, the enclosed arc lamp is the most satisfactory. The efficiency of most of the enclosed arc lamps is at least four times that of the best of incandescent lamps; it is less fragile, and is absolutely safe, as the globe encloses the arc so as to make it perfectly air tight. These lamps take either direct or alternating current, and burn on 110-volt circuits. For circuits of considerable length, three can be connected across 330-volt mains, and the lamps are cheap, durable and waterproof.

Much of the wiring in mine lighting is, of necessity, temporary, and all fixtures and lamps should be designed so as to be easily connected and removed. The contrast in the facility of such removals between this and any other system of lighting, is greatly in favor of electricity.

Lamp voltages, as previously stated, are usually 50 (48-60), 100 (96-108), and 110 (108-120). Lamps have been made for potentials as high as 250 volts but not for practical purposes. The line voltages which are usually reckoned standard are:

House voltages	50	Low potentials
	110	
	220	
Line voltages	500	
	1100	Commercial distribution potentials
	2200	
	5000	Long distance transmission potentials.
	10000	
	15000	
	20000	

Five hundred volts is considered dangerous, but voltage lower than this may be fatal under certain circumstances.

Wiring may be either overhead, the wires being supported by insulators or in an underground cable or conduit. The cable system is apt to be troublesome unless thoroughly protected from moisture, as there is difficulty in repairing (sometimes in locating) breaks. The cost of wiring for a power distributing system is small as compared to that of piping for steam or compressed air. This cost is usually based on the number of "outlets," or places where the line is tapped for power or light. It depends also upon the voltage and amount of current carried, the character and dryness of the soil or rock in which the mine is sunk, etc.

* * *

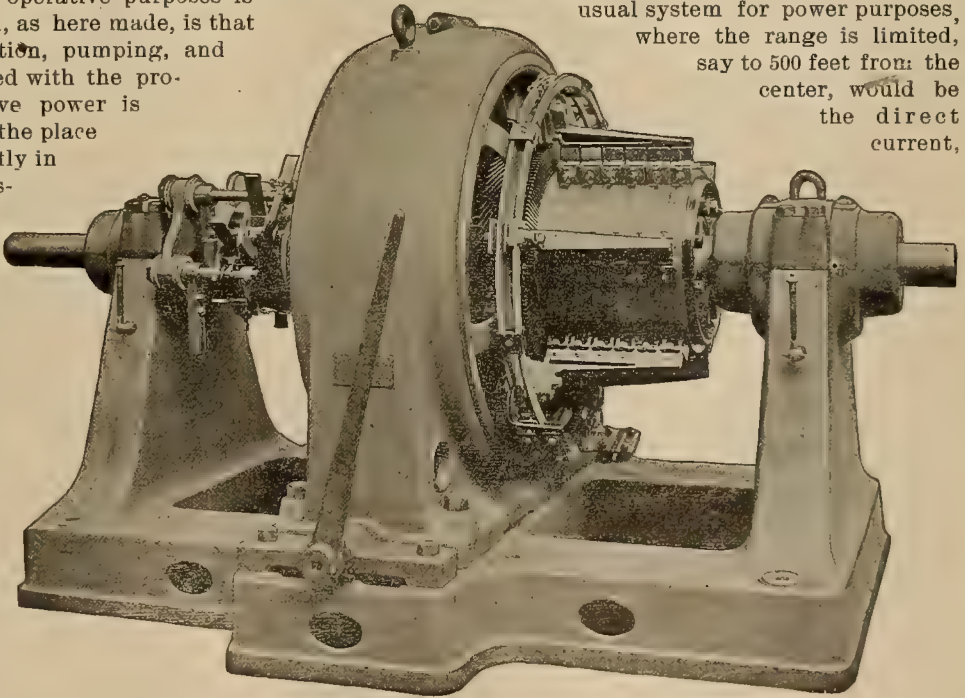
AUXILIARY POWER IN MINES.

The distinction between the two classes of auxiliary and operative power is one that is merely for purposes of convenience. The conditions governing the design of the electrical machinery in these fields are precisely the same, excepting that machinery for operative purposes is sometimes portable. The distinction, as here made, is that auxiliary power is used for ventilation, pumping, and other purposes not directly connected with the process of working the mine; operative power is that which operates the mine, taking the place of manual labor, and resulting directly in the output. The subject of power transmission in mines has been ably covered in the series of papers written by Mr. Rankin Kennedy, which, however, are more applicable to English operations than to those of this country. Mr. Cyrus Robinson, at the joint meeting of the Western Pennsylvania Central Mining Institute, and the Ohio Institute of Mining Engineers, June, 1896, set forth the advantages of electrical machinery, and concluded that the electrical system is superior, as a whole, to any other system of transmitting power. In view of the progress that has been made since that paper was read, the conclusion seems weak and trite. Affording as it does, a maximum of flexibility and simplicity, and rendering it possible to use successfully one generating plant to furnish power to all parts of the mines, and for all purposes, such as coal cutting, drilling, lighting, pumping, hoisting, haulage, fans, screens, conveyors, etc., the adavntages of the electrical system, with its consequent reduction in the cost of operating the plant, must be apparent at once to the mind of any business man. That this is the case is shown by the large number of mines in this country operated throughout by electrical machinery.

Progress in this direction has been less rapid in England. It is estimated that out of 212,000,000 tons of coal mined in Great Britain in 1895, not more than 750,000 tons were mined by machinery. During the year 1896, according to Mr. Robinson, over $1,000,000 worth of electrical machinery was installed in coal mines alone, in the United States. Fully 90 per cent. of this was for coal cutting machinery. In the development of the gold mines of British Columbia, electricity is playing an important part in the operation of drills, hoists, etc., the installations being usually in large units. One of the larger mines is supplied with a transmission system which runs a 300 kilowatt motor, which drives an air compressor with a capacity of forty drills. A 300 horse power induction motor is also used to run an electric hoist, on which the working load is eight tons.

Ventilating fans, blowers, etc., naturally come under the classification of auxiliary power. Perhaps in no application is the electric motor better adapted than for the rapid speed of a fan. For this service, the motor may be either belted or direct connected. A view of a fan belted to a Westinghouse motor is shown on page 22, while in pumping, the motor is on almost every occasion, geared down so as to get a suitably slow speed. Where the pump is designed for rapid work, a motor run by low frequency alternating current or by low voltage direct current, may be direct-connected. For the ordinary centrifugal pump, which is probably the cheapest and simplest, the common motor speed is suitable, as in the case of a ventilating fan, either belted or direct connected.

Modern progress in the design of electrical machinery has made it a matter of slight consequence, so far as the efficiency of the machines is concerned, what system of distribution is used. The various methods of distribution have been briefly mentioned heretofore, but the usual system for power purposes, where the range is limited, say to 500 feet from the center, would be the direct current, constant potential system, at a potential of about 200 volts. For mines covering a large acreage, alternating high potential current should be carried to the several shafts, and thence transformed down to 100 or 200 volts and distributed. If local conditions require direct current, a rotary transformer instead of a static transformer must be used. Direct current motors are made for either 110 (100), 220 (200), or 500



ROTARY TRANSFORMER FOR ELECTROLYTIC PURPOSES.

volts. These are the voltages commonly considered standard, and in planning the distribution, due regard should be paid to the fact.

* * *

OPERATIVE POWER IN MINES.

THE variety of uses to which power is applicable in the operations of mining are almost unlimited. Labor saving devices have been introduced more slowly in this class of work than in many other industries, for the reason that the nature of the labor is such as to require portable or semi-portable apparatus. Steam, water, and compressed air are noteworthy for their lack of portability. Electricity, however, has developed chiefly in that direction, and of all forces, is the most adaptable to temporary work.

The machinery of mining comprises an immense variety of tools, and in the different kinds of mining enterprises the variations are as great as in any different industries. There are the purely portable tools, the drills, picks, etc.; the manufacturing machinery, stamps and crushers; chemical apparatus, and a host of other classes of mechanisms by which time and money are saved.

For such portable tools as are used by each workman in his labor, most sources of power are rather a hindrance than a help. Clumsy piping, traps, drips, and drains, with the complication of pumping apparatus, are well calculated to make the victims curse the whole breed of so-called labor saving machinery. Electric power needs but the almost invisible, flexible, silent wire to carry on its work. Even in cases where the tools have been designed for some other source of power, the advantages of electricity have been so plainly seen by practical miners, that the effective motor has been called into play to supercede the wheezy, croupy compressor.

Such a substitution has been considered in a paper on "Coal Cutting Machinery," by Cyrus Robinson, M. E., published in "Mines and Minerals" of May, 1898. The system comprises an electrically operated portable compressor, driven by an electric motor, and the present form of compressed air pick machines. It is well known that in standard compressor plants a very large percentage of the loss is due to the necessity of cooling the air before it is discharged to the receiver, this in turn being followed by the troubles in freezing as the air and temperature are expanded in use. With the arrangement proposed, the air would be used at practically the same temperature obtained by compressing without cooling, and in use would be expanded down to a temperature slightly below that of the surrounding air; in this way an increase of efficiency would be obtained of at least 30 per cent. This in turn means that a compressor of about 30 per cent. less capacity would be required where the air is used without cooling. The designs for an equipment of this kind show that everything required for the operation of two pick machines can be mounted on a truck which could be easily pushed around by the machine runner and his helper, together with the machine itself, and would therefore not be any more cumbersome to handle than the standard breast machine. The advantages claimed for this arrangement when used in connection with electric plants are: No hand-mined coal; maximum efficiency from the breast machines, as they can be used entirely where the conditions are most favorable, and the pick machines used for room turning, robbing, and faulty work; larger yield of coal per acre; less timber for propping, as the work could be kept up much closer and sections of the mines worked out rapidly.

In the metallurgy of gold, the adaptability of the electric current for the cyanide or other electrolytic processes, has been well demonstrated. A type of machine like that illustrated on page 23 is used to supply the electrolytic current. The nature of the operation requires a very large current at a low voltage, hence the large brush area at the left or delivery side of the machine. This is a rotary transformer, being supplied with alternating current from high potential mains, through a static transformer as a mediary.

(Continuation in next number.)

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

ELECTRICAL SUPPLIES OF EVERY DESCRIPTION.

THE card of the John M. Klein Electrical Works appearing on one of the regular advertising pages, calls attention to one of the oldest and best established electrical supply houses on the Pacific Coast, and its reputation is one of thorough fairness and stability. Its standard line of business has for many years been in the direction of telephone and telegraph supplies, but of late it has been reaching out into the general electrical supply trade, until now it has a very extensive stock, including supplies for every branch of the electrical business.

Reference to specific features and appliances will be made from month to month in the advertising pages but at present it may be well to point out that among the recent valuable agencies acquired by John M. Klein's Electrical Works are those for the Jandus Electric Company of Cleveland, O., and for Partrick, Carter & Wilkins, successors to the Partrick & Carter Company of Philadelphia, which, for nearly two decades, has stood foremost in America in the manufacture of electrical house goods, annunciators, alarms, bells, etc. Of all the various lines of stock carried by Klein's Electrical Works none is more complete than the stock of house fittings of the Partrick, Carter & Wilkins Company.

The Jandus Electric Company is the manufacturer of the Jandus enclosed alternating current arc lamp, which is pleasing in design, thorough and reliable of workmanship, noiseless in operation, high in efficiency, and, above all, it is at all times, a perfectly reliable and satisfactory burner. As is the case with the Partrick, Carter & Wilkins goods, a large consignment of the Jandus arc lamps is always in stock, thus insuring promptness in filling orders, however large.

TABLE OF CONTENTS.

Editorial

A New Dress........ 19
Efficiencies, Actual and Theoretical........ 18
European Industrial Conditions........ 18
Petroleum in Southern California........ 19

Electro-Therapeuty

Anæsthesia Electrically Induced........ 10

Financial

To Reduce General Electric Share Capital........ 9

Fraternal

Proceedings of the Second Annual Convention of the Pacific Coast Electric Transmission Association........ 10
The Pacific Coast Gas Association........ 17

Hydraulics

On the Electrical Operation of Conoidal Centrifugal Pumps, by John Richards........ 8

Industrial

Electrical Supplies of Every Description........ 24
To Prevent Line Leakage........ 17

Mining

*Electricity in Mining—III
  Lighting of Mines........ 22
  Auxiliary Power in Mines........ 23
  Operative Power in Mines........ 24

Miscellany

*Electric Motors in the Stable........ 20

Passing Comment

A Noteworthy and Striking Article........ 19
Cost of Producing Electricity........ 19
Electric Properties of Glass........ 20

Personal

*Lighthipe, James Alfred........ 21

Transmission

Random Notes on Extremely High Potentials, by Leon W. Bly........ 5

THE JOURNAL OF ELECTRICITY.

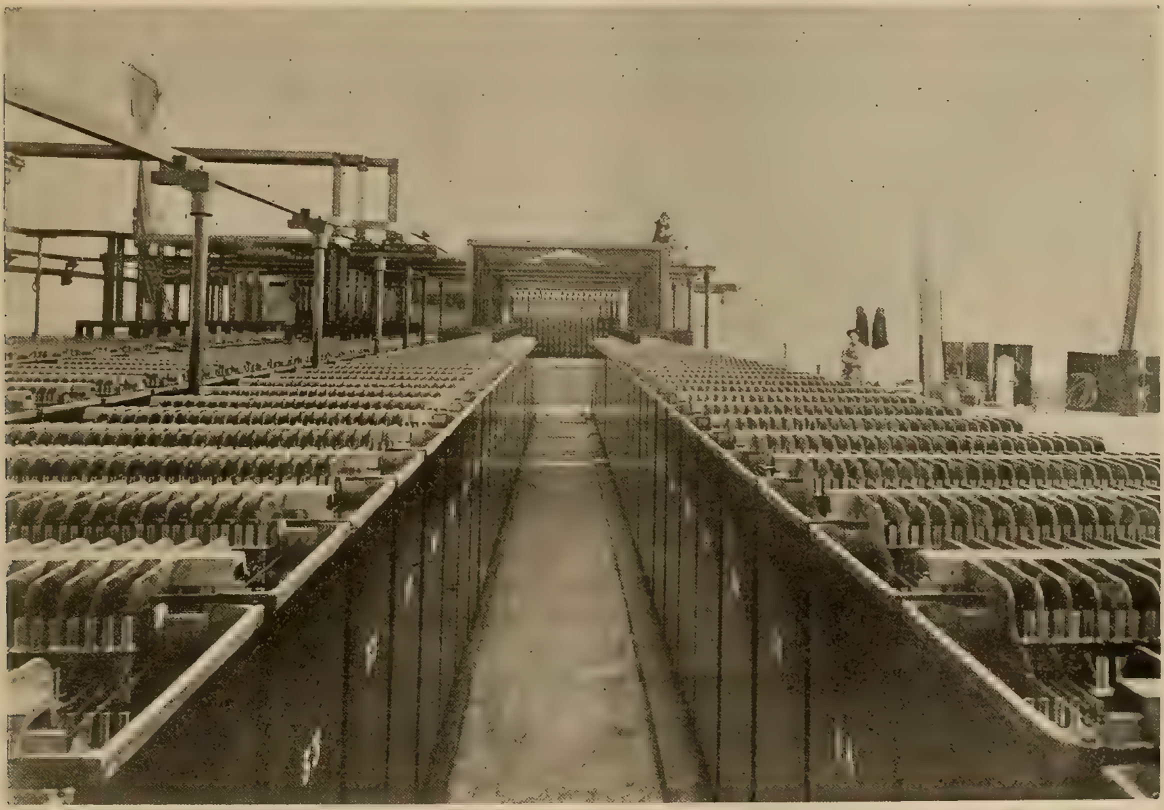
VOLUME VI. SAN FRANCISCO, AUGUST, 1898. NUMBER 2.

Electric Storage in an Edison Station.

BY GEO. P. LOW.

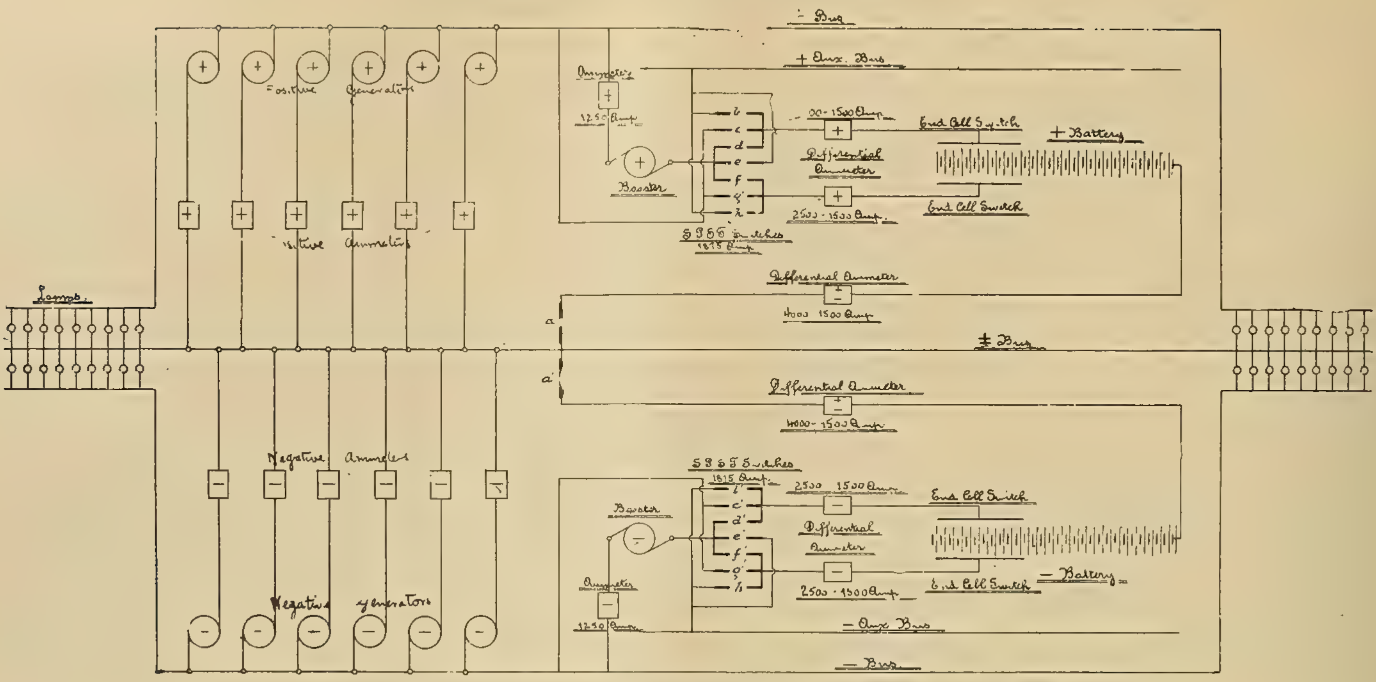
EVER since the generation and distribution of low tension electric currents for commercial incandescent lighting purposes became an established industry, great need has been felt for a means of electricity storage in order that uniformity in regulation may be secured; that the batteries may carry the peak of the load; that the engines may always be worked at a close approach to their rated capacities, thereby improving the load factor; and that, in brief, the conditions under which central stations are operated may be made to closely parallel those under which steam plants exist in driving mill loads; or, viewed again from a strictly electrical standpoint, that electricity works may be possessed of the advantages held by gas plants in the matters of generation, accumulation, and distribution. How successfully these aims have been realized will be learned from the following pages descriptive of the installation features, and the practical results obtained therefrom, of one of the most modern and complete storage battery plants ever erected in America for service in connection with a large Edison three-wire system. Moreover, its size is only exceeded by the battery of the Chicago Edison Company, but is equalled by the Philadelphia and Hartford installations.

The Edison station of the San Francisco Gas and Electric Company has a nominal generator output of 2200 kilowatts in six sets of direct connected marine type triple expansion engines, five of which each have a capacity of 2 x 200 kilowatts, the remaining set having a capacity of 2 x 100 kilowatts. The winter of 1896 witnessed the loading of these generators to their maximum capacity, and the question of providing more station capacity resolved itself into a choice between enlarging the steam and electrical equipment, or installing a storage battery without further increase in the steam plant. In either instance real estate would have to be acquired and a building erected for the enlargement of the station, and after receiving a report from its superintendent, Mr. C. O. Poole, who had been sent east to examine into the use of storage batteries in Edison stations at New York, Boston, and Philadelphia, the company determined on the installation of a battery having a capacity at least equal to the output of one of the largest steam engine sets in the Edison station at San Francisco. The plant as installed, however, is capable of delivering a



ONE HUNDRED AND FIFTY 2½-TON "CHLORIDE" CELLS.

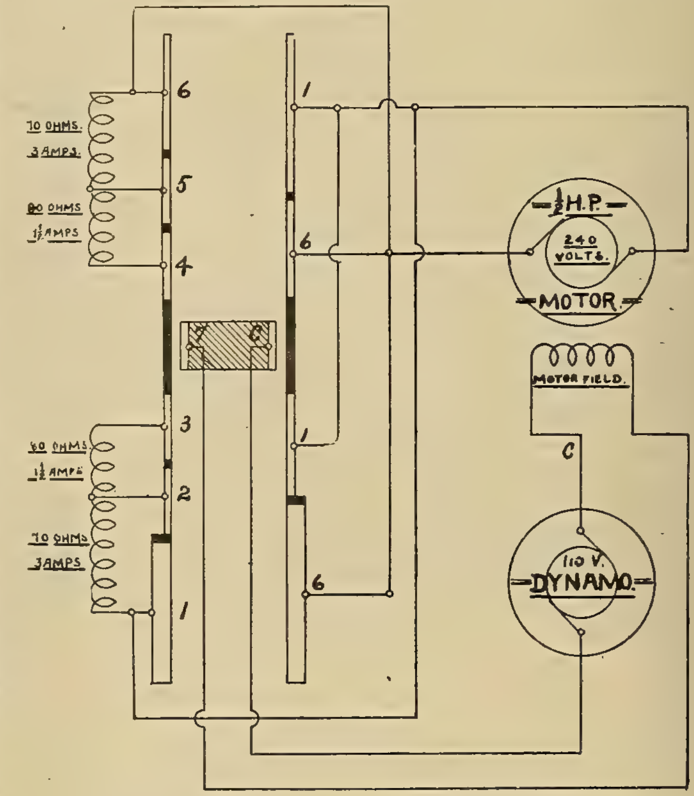
ACCUMULATORS IN THE SAN FRANCISCO EDISON STATION.



GENERAL WIRING SCHEME FOR ACCUMULATORS ON AN EDISON THREE-WIRE SYSTEM.

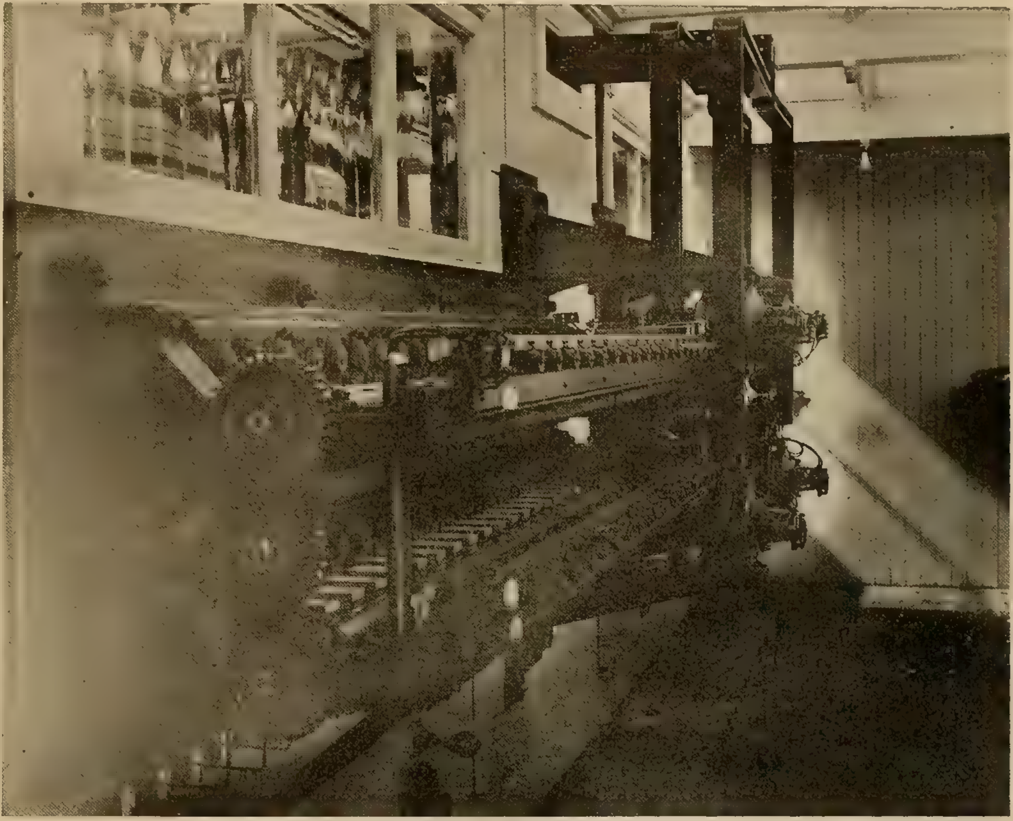
maximum of nearly 1000 kilowatts for an hour, which generally covers the period of the load peak. The battery was installed in the summer of 1897 in a substantial brick building 70 by 80 feet in size, erected on property adjoining and immediately north of the Edison station, and facing on Stevenson street. It is an open building, thirty-two feet in height, with notches cut in the side walls for girders and buttresses for piers upon which to build the second floor for the support of two other three-wire series of batteries when necessity requires. The roof is of wooden truss construction, oiled on the under side, tarred and graveled on top, and provided with a wide light and ventilating cupola, having swinging windows for ventilation, along the peak. The building will ultimately contain four three-wire battery installations, each of the size of the plant now to be described. Complete engineering data regarding the number, size, and characteristics of the storage cells, is appended hereto, and this, in conjunction with the accompanying diagrams, will be found to be thoroughly comprehensive.

Before entering into the very fascinating details of this beautifully working installation, it is well to point out for the benefit of those who are familiar with lines of electrical engineering other than Edison station work, that Edison generators deliver potentials approximating 110 volts to the three-wire system. In the present instance the potential delivered is 116 volts, but the ofttimes great length of the underground feeders and the heavy currents carried, occasion drops in electromotive force that necessitates the raising of the pressures at the station ends of the underground feeders to close in the neighborhood of 140 volts. These increased pressures are supplied from independent or auxiliary 'bus bars whence the current is taken to the remote districts by boosted feeders direct, no light or power service whatever being taken from any of the feeders. The outlying districts are thus supplied with practically the same potential as those nearer the station. The potential of the auxiliary 'bus bar is about twenty volts above that of the main 'bus bars, and this increased pressure is derived sometimes direct from an independent set of generators running at higher voltage, but more often by the use of a combination of a three-wire motor-generator set, known by the expressive name of "booster." This consists merely of a 220-volt motor having at each end a low-volt direct connected generator, each of half the capacity of the motor, and the armatures of these generators have sufficient carrying capacity to take the whole volume of current for the auxiliary 'bus bars and raise its potential by fifty volts or so, before delivery to the auxiliary 'busses. In other words, current is taken from the main 'bus bars and run through the armatures of the booster generators, before being delivered respectively to the positive and negative auxiliary 'busses, thus making the auxiliary 'bus voltage higher than the main 'bus voltage by the value of the potential generated in the armatures of the booster generators.



THE REGULATOR CONTROL SWITCH IN ELECTRICAL DETAIL.

The act of charging a storage battery resembles the putting of current into a shunt dynamo so as to drive it as a motor, in that when the charging generator and storage battery are at equal voltage and connected positive to positive, no current flows from one to the other; but to get current into the dynamo to drive it as a motor, the electromotive force of the source of supply must be raised above that of the dynamo, when the latter will take current and "mote." Thus it is that the storage battery receives its charge; viz.: from a source of electricity at higher potential than that of the battery, and in practice, the amount of this excess varies; first, upon the state of the battery as to its condition of charge, and second, upon the rate of charge it is desired to give. Ordinarily, the potential used for charging that section of the battery subjected to the greatest use is about the same as that of the auxiliary 'bus bars, and should it not be so, the battery potential may be adapted to conform to that of the auxiliary 'busses by cutting in or out end cells as will be shown. Several important points are to be considered in laying out the use of a storage battery in conjunction with an Edison three-wire station. First, the batteries must be arranged so as to be worked on either the main or auxiliary 'bus bars alone or in multiple with the generators; they must be capable of either giving or taking current at all times according to fluctuations of load; they must be able to take charge at one potential and deliver current at another potential simultaneously, and they must be as readily controlled by the switchboard attendant as a generator. Two series of batteries, the positive and negative sets, are connected in across the three-wire service upon the same underlying principles as Edison generators are coupled up; each of these series consists of seventy-five cells, nineteen of which, used for regulating purposes as described, are termed the "end" cells.



END CELL REGULATOR SWITCHES.

THE BOOSTER.

The functions and details of the positive and negative cells are identical in all respects, hence the positive set only will be discussed.

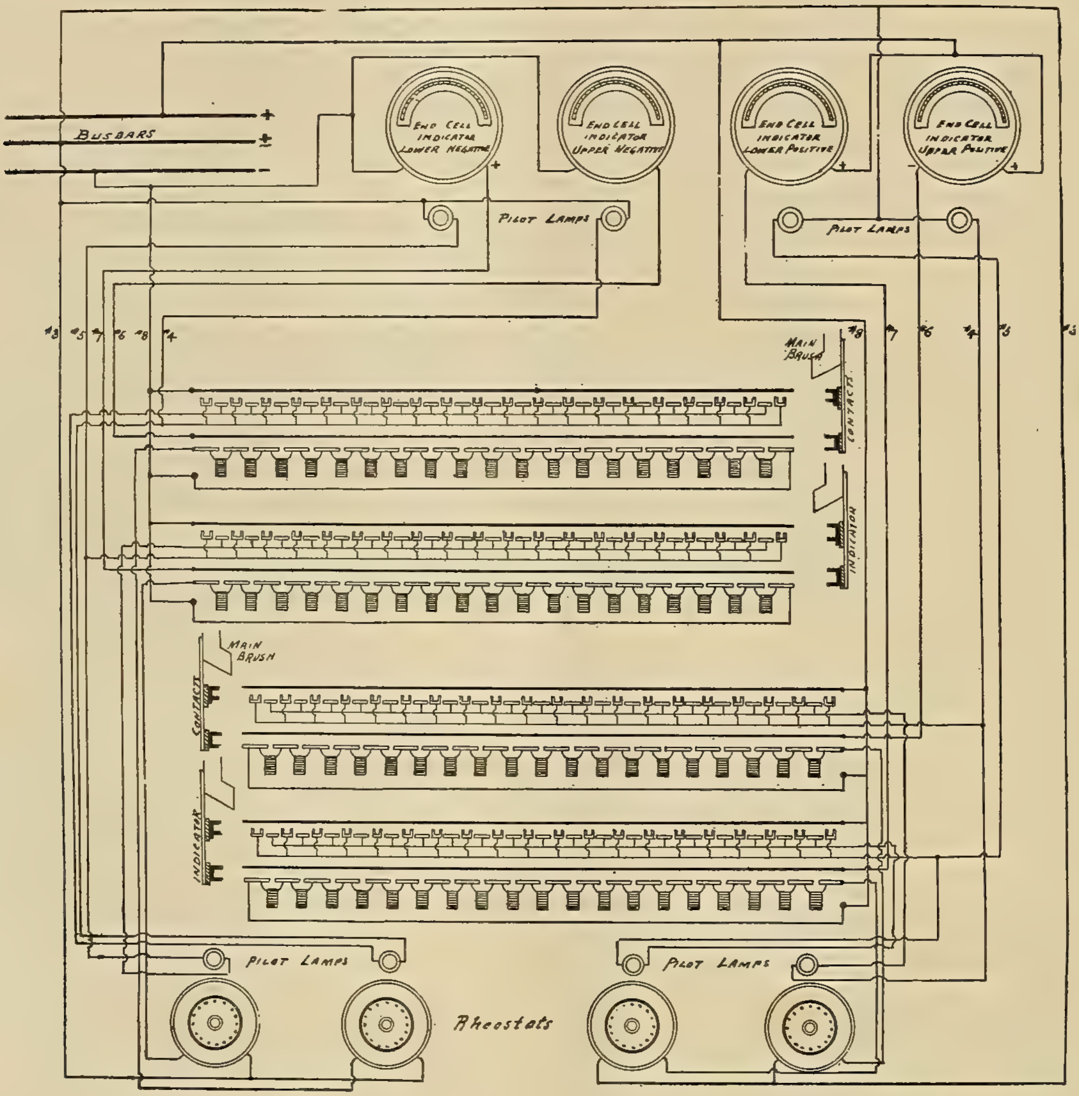
Taking therefore, the upper battery of seventy-five cells, as shown in the upper half of the general circuit outlines on the preceding page, it will be seen that its negative end is connected to the neutral 'bus bar through the single pole single throw neutral 'bus switch *a*, while the storage cells along the positive end of the battery are connected by means of the two end cell switches diagramatically shown. As these switches are entirely independent in action, it is easy to perceive how the upper end cell switch for instance, may be run further along the series of battery, raising the battery potential between the cell switch and neutral 'bus to the same voltage as that between the auxiliary 'bus and the neutral. Similarly, the lower end cell switch may be placed on, say, the sixtieth cell when, (if the condition of charge and the rate of discharge are such as to give an electromotive force of two volts per cell) the battery potential will be 120 volts, and the battery will carry its proportion of the load on the main 'bus bar by closing the switches *a* and *g*. All switches are of the single pole, single throw type, and each has a rated capacity of 1875 amperes.

Thus it is that if the booster is in operation and the two end switches are in the position just described, the closing of the switch *d* will cause the battery to be under charge simultaneously with its discharge on to the main 'bus through the switch *g*. By opening this switch *g*, then moving the lower end cell switch along so that the battery voltage corresponds with the auxiliary 'bus voltage, or is a trifle above it, the closing of the switch *h* will cause the battery to deliver current to the auxiliary 'bus bar while the battery is still under charge. Now open all switches, and upon closing switch *e* the booster will deliver current to the auxiliary 'bus. With *d* open and *a* and *b* or *a* and *h*, or *a*, *b* and *h* closed, the battery will deliver current to the auxiliary 'bus bar; with only *a* and *c*, or *a* and *g*, or *a*, *c* and *g* closed, the battery discharges current to the main 'bus; and with only *a*, *c*, *e*, and *g* closed, the booster delivers current to the auxiliary 'bus and the battery delivers current to the main 'bus, always, of course, with the end cell switches in proper positions.

It is while the switches are in the position last indicated, with the booster either in or out of service, and the end cell switches so that the battery potential is at normal voltage, that the battery does its best work as a potential regulator, and at the station are exhibited two recording voltmeter charts which attest the high efficiency of accumulators when used for the purposes of perfecting regulation. The first chart was taken on October 27, 1897, when manual regulation was in vogue in the San Francisco Edison station. and the second chart was taken ten days later, just after the batteries were put in service. The later card shows a remarkable improvement in the voltage line. It is interesting to watch the differential ammeters when working under these conditions; the needles hover about zero, first above and then below, giving and taking as high as 150 amperes, more or less, on either side of zero, as the main 'bus bar voltage varies from the normal because of load changes. The battery acts precisely as a carriage spring which softens down the jolts in a road, or as a fly wheel which tends to preserve constant speed because of its momentum, or as an air chamber on a piston pump which at all times mellows the energy of the strokes into evenness of flow.

To check the play of simile that practice may work, it should be explained that the effectiveness of the storage battery as an aid to regulation rests primarily in its extremely low resistance, so that when a large Edison generator is coupled in multiple with a storage battery, each of the same voltage, the potential of one is cushioned against that of the other, and so delicate is the elasticity of the balance that the potential difference of even a few millivolts disturbs the equilibrium, but this disturbance is instantly restored to its former stable condition by the C^2R losses occasioned by the property of the battery in absorbing or delivering current in direct ratio to the applied electromotive force. The world of science has no more striking exemplification of the balancing of forces than the instance here presented.

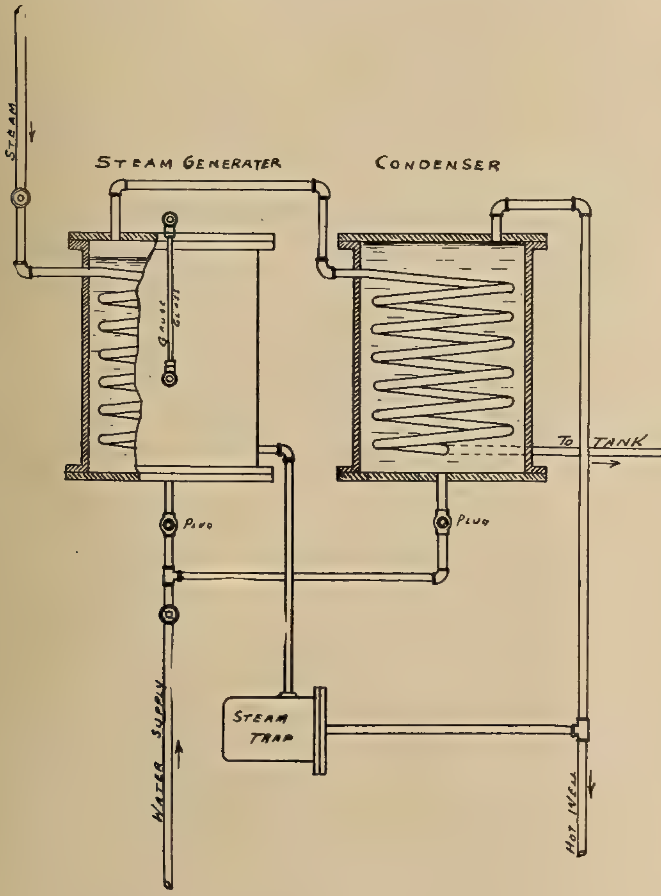
It must be evident that the successful handling of a large battery installation depends in a great measure upon the celerity and completeness with which pressure readings can be taken, and how this is accomplished will be seen from the diagram on page 30, on which the 'bus bar, booster, end cell, and main switching arrangements are laid out as heretofore described, but circuits for the voltmeter connections are added in detail. The contact points of the voltmeter switches are for the main 'bus, auxiliary 'bus, upper end cell switch, lower end cell switch, and boosted potentials respectively, for, as shown, both the positive and negative sets of batteries. In addition, end cell pressure switches, (not shown except in the switchboard panel appearing on the following page) are provided for giving the voltage of any end cell individually. The points upon which potential readings are to be had are commutated by means of two five-point voltmeter switches of the ordinary type.



CIRCUITS OF THE END CELL INDICATOR AND REGULATOR TELL-TALE SYSTEMS.

The end cells of the more familiar classes of storage battery installations, such as isolated plants, are controlled direct by an end cell switch placed on the switchboard; that is, from the terminals of each cell a heavy wire is run to its proper contact on the heavy amperage commutating switch on the switchboard, and by means of this switch the end cells are cut in or out direct. The simplicity and efficiency of this method of cell control are evident, and its only disadvantage is that of comparatively heavy investment in copper—only from five to twenty per cent of which is ever in use at any given time—but with storage batteries in central stations of the size of the present installation, the impracticability of placing forty end cell switches, each having a capacity of not less than 2000 amperes, on the main switchboard, as well as the great investment in copper that would be necessary to cable in the end cells to the switchboard individually, render it advisable that they should be commutated at or very near the battery. In the San Francisco Edison station the end cells are placed in a switch room partitioned off at one end of the main battery room and to which the main battery terminals as well as the end cells are carried. These terminals and leads consist of copper bars, the former measuring one inch by three inches in cross section, and the latter measuring one-half inch by three inches, and having therefore an area of approximately 3,820,000 and 1,910,000 circular mils respectively. It is these conductors that are run overhead, as shown in the initial illustration, and which at the point of entering the end cell switch room give the end of the battery room aisle the rather incongruous appearance of being provided with an organ pipe.

Considerable difficulty was experienced in photographing the interior of the switch room, but the view presented on page 27 shows the two sets of regulating switches, one for each side of the three-wire system. The switches, or more properly the sliding brush contacts, are double, one above and one below, and each consist of a bundle of strip copper measuring two inches by three inches over all and bent into U shape, so that one leg of the U bears end down on the contact forming the terminal of an end cell and the other leg bears on a bar extending along the whole sweep of the switch. This bar constitutes the terminal of the 'bus bar, by means of which the battery current is carried to or from the regulating switch to or from the main switch board for discharging or charging purposes. The switch, which has a sweep measuring 72 inches and is capable of being covered by the mechanism about to be described, in 30 seconds, is rigidly mounted upon an insulated nut traveling upon a screw running axially with the battery terminal contacts and bar, and this screw is operated by a one-half horse-power Lundell motor through worm gearing so arranged that by cutting in an idler gear the motor may be cut out and the two regulating switches of a set may be operated manually either separately or together through a hand wheel, as is shown in the general circuit diagram. There are four of these end cell regulating switches, two for the positive and two for the negative side of the three-wire system, and each is separately controlled and operated by an independent motor.

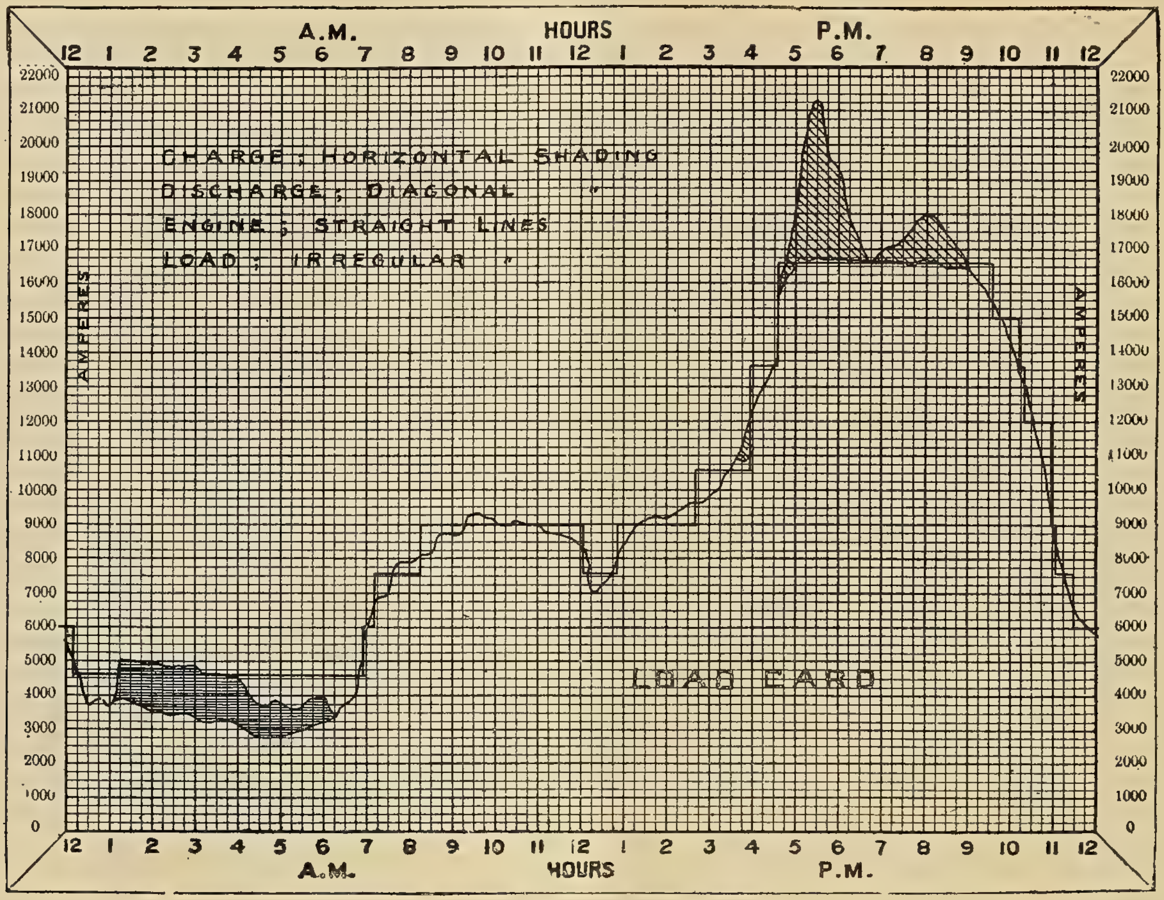


DISTILLING WATER AUTOMATICALLY.

BATTERY PANEL ON THE MAIN SWITCHBOARD.

As has been intimated, the operation of the motors driving the end cell switches is controlled by the attendant at the main switch board by means of an edgewise lever switch for each of the four end cell regulators, he being guided by a pilot lamp in its manipulation. For simplicity's sake only the motor connections will be considered at present.

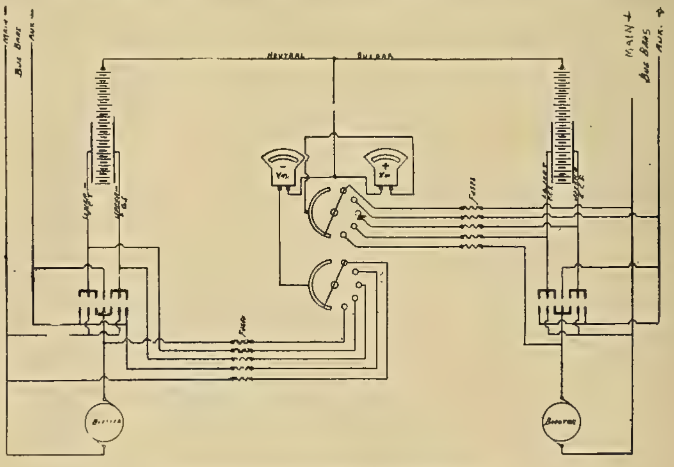
In the diagram of connections for the motor contolling switch appearing on page 26, the dynamo represents the source of current, which in the present case is the main 'bus-bar potential of 120 volts. The motor is a simple series machine whose fields, in series with the source of supply, terminate respectively in the sliding contacts *7 C* of the edgewise lever switch represented in the diagram by diagonal shading. These contacts are on the lever and slide along the runways. When the lever is raised the motor runs in a direction causing the end cell brushes (supported on the traveling nut) to cut in more cells; when the lever is lowered, the operation is reversed and the end cells are cut out. On raising the lever the sliding contacts *7 C* come in contact with plates *4* and *6* respectively, which, it will be seen on tracing the connections, merely excites the fields through 150 ohms of resistance. Advancing the switch to plate *5* cuts out eighty ohms of the resistance, while the current is not thrown into the 240-volt armature until the contact *C* is fully on plate *1*, immediately after which the remaining seventy ohms of resistance is cut out by the "shorting" of plates *5* and *6* by contact *7*, when the motor is at full speed. The process is reversed on restoring the lever to its normal position, except in that as the sliding contact *C* bridges plates *1* and *6*, the armature is short circuited while the fields are excited, which causes it to stop instantly. Throwing the lever downward executes the same circuit procedure except in that it reverses the direction of armature rotation. The 240-volt armature is used on a 120-volt circuit in order to prevent sparking at the brushes while the armature is under short circuit during the excitation of the fields, as well as to give the preferably lower speed.



LOAD CARD, DECEMBER 18, 1897.

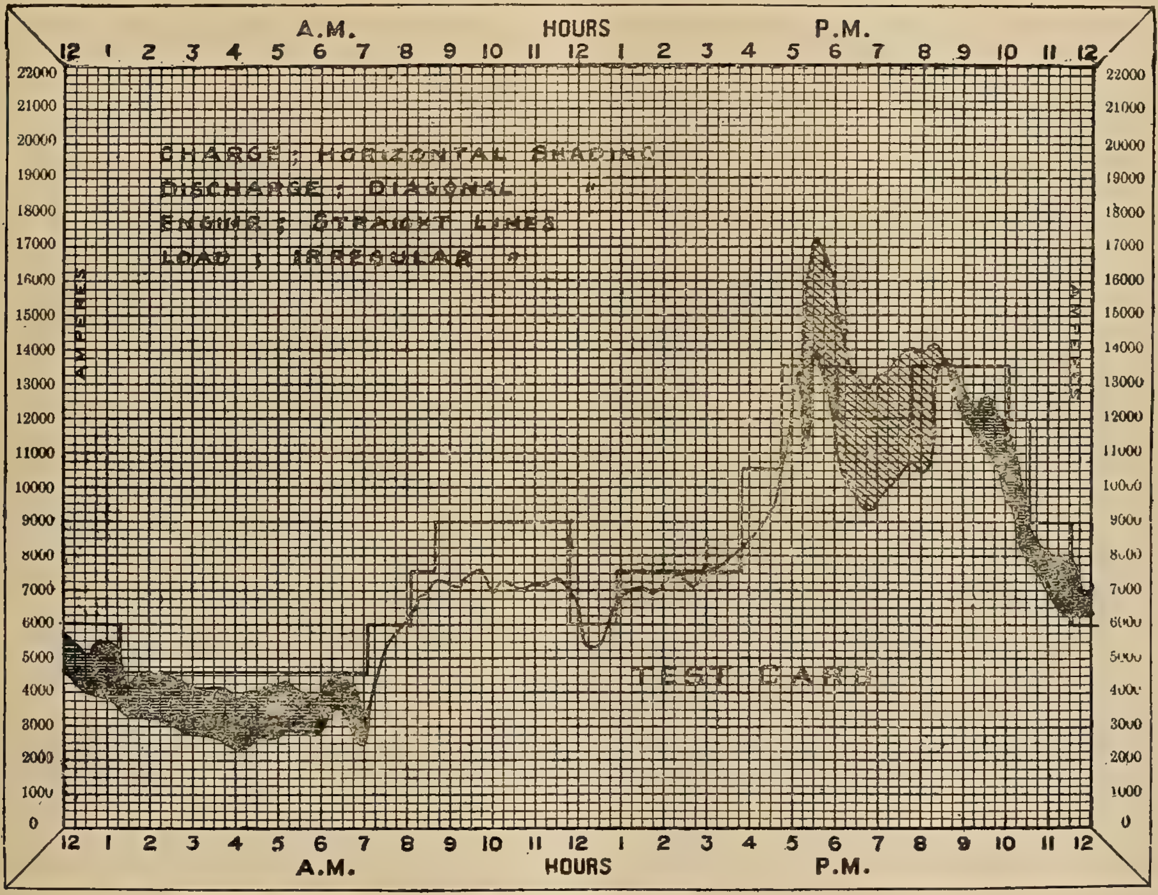
The disaster that would result to the storage cell and the controlling switches from the dead short circuiting of the battery, which would cause a "short" of several thousand amperes, makes it necessary to render such an occurrence impossible, and the means by which this is accomplished forms an interesting feature of the installation. Though the commutation of end cells resembles the varying of resistance in a rheostat, the two processes are similar only in appearance. It is almost as essential to good lighting service that there should be no break in the commutation of the end cells, as it is necessary to the operation of a dynamo in service that the resistance in its rheostat should be increased or decreased step by step without breaking the field circuit. In the rheostat, however, the short circuiting of the contact strips forming the resistance terminals is of no consequence, but the short circuiting of the terminals of a ton and a half storage cell means a discharge of considerably more than 10,000 amperes, hence it is not to be permitted under any circumstances. The problem is, then, to commutate the end cells without short circuiting them, so that the battery discharge will not be interrupted. To do this the U-shaped brush as it slides along driven by the traveling nut, must bridge the two plates forming the poles of an end cell—otherwise heavy sparking will occur on breaking the circuit and intolerable jumping of the potential would accompany the cutting in or out of every cell—and short circuiting with its evil consequences is averted by splitting the sliding brush and establishing an electrical connection between the two sections of the brush through a strip of German silver seventeen inches long by one-sixteenth of an inch thick by one inch wide. In service it carries 1750 amperes, hence as the sliding brush switch passes, it throws a partial short circuit of about .001 ohms upon each cell, and in so doing renders commutation of the end cell at once sparkless, uninterruptive, and non-injurious to either cell or switch.

The traveling break switch is not, however, the comparatively simple contrivance thus far indicated, but although it is not especially intricate or complex, it is sufficiently so to be difficult to describe or present diagramatically. The line drawing on page 28, showing the circuit connections for the "tell-tale" indicator and the pilot-lamp system, appearing at the ends of the



THE MAIN VOLTMETER CONNECTIONS,

four series of the nineteen resistance coils, shows the outline form of a half of one of the two main sliding brushes. The split referred to as being in these brushes, is not central but occupies practically a third of the face of the contact surface, so that as the brush advances to cut in an additional cell, the smaller segment of the brush acts as a trailer. When the main segment is well on the positive contact plate of any cell, the trailer segment is on its negative contact, hence the partial short circuiting of the cell through the seventeen-inch resistance strip; before the main segment is fully on the positive contact, the trailer segment leaves the negative plate and the spark that occurs from the breaking of the 1700-ampere partial short circuit is taken up by a secondary trailer which closely follows the smaller segment of the brush. This secondary trailer is of carbon and bears upon the ends of the cell contacts. The main contact brushes, therefore, run without sparking, and the spark which occurs at the secondary trailer does no injury as it breaks between carbons. Two bars, each supporting two downwardly-projecting, close-circuited points, follow along with the main brushes, but have no connection therewith beyond their tell-tale functions.



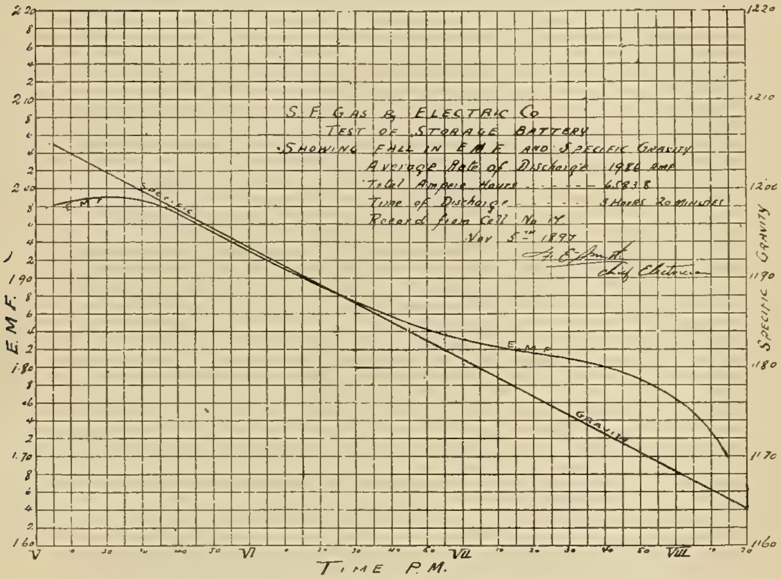
TEST CARD, NOVEMBER 5, 1897.

When it is remembered that the motor operating the sliding brushes is controlled by the attendant at the main switchboard in another building, and when it is realized that the leaving of the switch in any position other than being squarely on a cell terminal, would cause the rapid discharge of the battery from the partial short circuiting previously described, the necessity for having a device which will at all times indicate the exact position of the sliding switch, will be appreciated. Of course, this might be done by mechanical means or through synchronous motors were it possible to reduce them to absolute synchronism at all speeds or either direction of rotation; but the mode adopted is based on the same principle as is used with tell-tale devices on warships, where indicators placed on the bridge give information at all times concerning, for instance, the position of the rudder, or the speed and direction of rotation of the engines.

How this is accomplished will be understood by reference to the diagram on page 28, on which appears, at the top, the three-wire main 'bus bars, the four end cell indicators, and the four pilot lamps for the indicators, respectively. These devices are on the main switchboard in the Edison station proper, while in the battery room are located the remaining devices appearing on the diagram. The circuits shown are those for handling the thirty-eight end cells of the whole battery, and as each of the two series of end cells has two end cell switches as already described, there is evident necessity for an indicator for each of the four end cell switches. These switches are known as the lower and upper negative and lower and upper positive end cell switches respectively, and each such switch has its own indicator as shown in the diagram. The four pilot lamps appearing in the lower portion of the diagram are used for resistance purposes to cut down the voltage applied to the pilot lamps on the switchboard panel; hence, strictly speaking, they are not pilot lamps at all, but are resistance lamps, and as such are located in the switch room.

The principle upon which the indicators are operated is simple: nineteen coils of German silver wire looking like the electro-magnets of telegraph sounders, are placed in series across one side of the three-wire system, also in series with a rheostat by means of which the current is adjusted so that there will be a drop of exactly five volts across the terminals of each German silver resistance coil. The indicators are merely Weston circular type voltmeters calibrated to five volt divisions, the divisions being consecutively numbered from 56 to 75 inclusive—which are the numbers of the nineteen end cells. If now the negative terminal of the lower negative end cell indicator be connected to the negative of the three-wire system as shown in the diagram, and the positive terminal of the indicator be connected to a brush which trails along, completing the circuit through contact plates forming the terminals of the resistance coils, the number of the coil on which the brush is resting will be shown on the indicator, provided the indicator and coils have a common source of current supply. The diagram shows the circuit connection for accomplishing this, but instead of the traveling contact referred to as brushes, the circuit between the coils and indicator is completed through the indicator contacts shown, which are rigidly secured to, though insulated from, the main brushes of the end cell switch. The variable terminal of the indicator consists of a straight brass bar paralleling which, and separated therefrom by about half an inch, are the nineteen contact plates representing the terminals of the resistance coils. The indicator contacts are ∩-shaped bridging contacts which run along this bar and the plates according to the position of the main brush, thereby placing some particular plate in electrical connection with the variable terminal of the indicator.

The indicator, therefore, only shows the number of the end cell that is in actual service, but does not convey to the switchboard operator definite information concerning the position of the main brushes. This is done entirely by means of the pilot lamps through the arrangement of electrical details according to the scheme presented in the upper series of devices shown in the diagram. A long, straight bar constitutes the variable terminal of the pilot lamp, as it was in the previous instance of the indicator, and upon this bears one leg of another ∩-shaped bridging contact, the remaining leg of which closes the circuit alternately through U-shaped or straight bar terminals. When the traveling contact closes the circuit between the U-shaped terminal and the long horizontal bar, full voltage is thrown upon the pilot lamp causing it to burn to full candle power; when the traveling contact short circuits the short plate and the long bar, the pilot lamp in the switch room, as shown at the bottom of the diagram, is cut in in series with the pilot lamp on the main panel, causing the last named lamp to burn at one-half candle power; when the traveling contact rests on the fibre plate between the prongs of the U-shaped terminal, the circuit to the pilot lamp is opened, while at all other positions it is closed—a point which suggests an inaccuracy in the diagram in that the short bar-contacts between the U-shaped contacts should be as broad as the latter are deep



SPECIFIC GRAVITY AND ELECTROMOTIVE FORCE LINES, TEST NOVEMBER 5, 1897.

When the pilot lamp is at full candle power, the main brush is squarely on a cell terminal and no current is flowing through the heavy German silver partial short-circuiting resistance, but when the pilot lamp is at half candle power, the sections of the main brush are short circuiting the terminals of a cell, and half candle power in the pilot lamp is, therefore, an indication of the fact that the main brush is in a position which it may occupy only momentarily or while the brush is in transit.

The manipulation of the end cell switch is a process requiring close observation of the pilot lamps and quick handling of the motor controlling switch. Switchboard attendants however, soon become very dexterous in this, and the main end cell switch is handled with the utmost precision, invariably being stopped within one-sixteenth of an inch of being squarely on a cell terminal.

The battery panel pictured on page 29 is inserted in the main Edison switchboard as shown. The panel is in three sections, the upper containing Weston station instruments, but from this two differential ammeters have been taken and mounted on the auxiliary switchboard so as to be more readily observed by the operator. The next panel carries at the top the two main ammeters at the sides of which are small voltmeters having a range of five volts for taking the voltage of individual end cells as described. Below these are the four end cell indicators, underneath which are the edgewise switches controlling the motors, the electrical details of which appear on page 26. The lower panel carries the heavy switches indicated by letters in the diagram showing the general wiring scheme.

The load and test cards shown on pages 30 and 31 respectively, are really self-explanatory, as they present a graphic record of the operation of the station on the days named. The five large engine generators in the station each have a rated capacity of 3000 amperes and the small engine set delivers 1500 amperes; hence, reference to the load card shows that at midnight two large engines were running, but that a few minutes after, one of the large engines was shut down and the small engine started. By one o'clock, a. m., the load had fallen to about 3700 amperes, leaving one of the engines underloaded by approximately 1000 amperes. At 1:15, therefore, the battery was put under charge, which caused the engines to run slightly overloaded until 3:15 o'clock when the load had dropped off so that the engines were running at their rated capacities. This condition prevailed until 4 a. m., when the charging rate was decreased for the purpose of preventing the excessive generation of gases during the conclusion of charging and the loss of energy that such generation of gases represents. From 4 o'clock until about 6:20 a. m., when the battery charge was completed, the engines were running underloaded by a maximum of twenty per cent., when the increase of the load caused the starting up of other engines at the hours indicated by the straight lines. How the engine line follows the load line in central station work is clearly shown in this diagram, from which it will be seen that from 7:15 to 7:30 a. m., from 8:15 to 9:15 a. m., from 11 a. m. to 12 m., and from 12:15 to 12:45 p. m., etc., a margin in engine capacity existed which might have been utilized for charging purposes, and that from 7:40 to 8:15 and from 9:20 to 10 a. m., etc., periods existed when the battery could have carried those portions of the load which were in excess of the generator ratings, but the well known flexibility in the capacity of a generator, coupled with the very slight amount of variation from the load line, made it of no material advantage to cut in the battery, although this was done for twenty minutes or so shortly before 4 o'clock in the afternoon as shown. At 4:40 however, the five large engines and the one small one were all in operation to their rated capacity, to-wit: 16,500 amperes, when the storage battery took up the peak of the load, reaching its maximum discharge of 4500 amperes at 5:30 p. m. It is at this hour in winter when the motor load overlaps the lighting load in San Francisco, while the second peak at 8 p. m. is commonly referred to as the theatre peak. The test card given suggests, among other things, the capability of the battery for enduring hard service.

There are several characteristics of a storage battery installation that are worthy of particular consideration, one of which is the rapidity with which it recuperates its electromotive force and capacity after a heavy discharge. The voltage of a storage battery is inverse to the discharge rate, and is also dependent to a lesser degree upon the amount of charge remaining in the battery, and this is shown graphically in the electromotive force line appearing on page 32, plotted from five-minute readings taken during the test run of November 5th, 1897. The irregularity of this voltage line is due to several causes, principal among which are the varying rates of discharge. The constant decline of electromotive force as the cell nears exhaustion, is marked, though when the voltage had reached its lowest point during discharge, if the discharge had been stopped, the voltage of the battery on open circuit would have been found to be considerably higher per cell than during discharge.

Evidently then, the electromotive force per cell forms a variable quantity not directly dependent upon either the charge or discharge rates or the quantity of charge in the battery, but fortunately the station attendant has in the hydrometer a perfectly reliable gauge for measuring the quantity of energy in the battery, and this gauge is as accurate as is the lineal one painted up the side of a gas holder. During the test referred to, the hydrometer was read with the voltmeter every five minutes, and from these readings the specific gravity curve was plotted in the absolutely straight line shown. A more reliable electricity gauge is therefore not to be conceived.

There remain but two other devices to be described, viz.: the condenser for supplying distilled water to replenish the loss in the battery electrolyte from evaporation, and the portable hydrogen generator for burning the lead lugs of the cells together. The latter is merely an adaptation of the ordinary form of hydrogen generator familiar in laboratories, but of larger capacity. It is automatic in action in that if more hydrogen is generated than used, the gas forces the sulphuric acid solution down from the cell containing the zinc spelter and up into an upper chamber, thereby stopping its generation. The condenser, shown diagramatically on page 29, is also automatic in action and has a capacity of delivering twenty-five gallons of distilled water per hour. It consists of two cast-iron cylinders of the form shown, resembling an ordinary type of feed water heater in construction. Live steam is introduced into the worm of the first cylinder, the water about which is taken from the city supply and converted into steam whence it is carried in the manner shown to the worm of the condenser in which it is condensed and taken to the distilled water tank. The steam generator is provided with a water glass in order that the water may not be allowed to reach the outlet. Cold water is introduced into the condenser from the same supply pipe, and on setting the stop-cock plugs immediately below tne generator and condenser respectively, as well as the stop-cock in the water supply pipe, the amount of inflow is gauged so that the loss of water from evaporation in the generators is compensated and the water level remains at a standstill. The water still was designed by an employee of the San Francisco Gas and Electric Company.

In conclusion of this description, it may be well to state that Mr. Joseph Wetzlar has recently given an excellent description of a modern process of battery manufacture,* from which it appears that the positive plate of the "Chloride" accumulator, which is used exclusively in the San Francisco Edison station, is of the English type known as the Manchester form. It consists of an active material of peroxide of lead, formed after the Planté method on a rosette or coil of rolled lead tape, corrugated and coiled automatically, and pressed into an antimonious lead frame or grid, which makes a practically non-corrodible, rigid and conductive support. The antimonious lead used in making the positive plates is first fed into melting pots which are fired by oil and hold about four tons each. Hinged cast iron moulds, with steel buttons corresponding to the holes in the grids are used, and the feed is orificed to fit a nipple which is connected to a lead pump delivering the molten lead to the mould so as to cast the grid at a pressure of about one hundred pounds to the square inch. The lead ribbon, which eventually becomes the active material, is received on reels in the form of lead tape, and is fed into a coiling machine that corrugates and cuts it into proper lengths, then coiling it into rosettes of the required size. These rosettes are placed in templates and driven into the grids by hydraulic pressure. The plates are then "formed,"—a process of charging and discharging at various rates uninterruptedly for several days—after which they are sampled for testing in the commercial laboratory before being shipped.

The name of this accumulator is derived from the chloride of lead entering into the pastilles forming the negative plate. These pastilles are keyed together with a frame of antimonious lead forced around them. The chloride used is received at the factory in the form of a white crystalline powder, 100 per cent. pure. It is melted at great heat in reverberatory furnaces holding about one ton each, and then ladeled into casting moulds, making square pastilles of four square sub-divisions, divided by two small grooves on each side, perpendicular to each other. At the intersection of each, in the middle of the pastille, is left a hole, and the pastilles, after being trimmed, are conveyed to the framing moulds. These are similar to the positive moulds, and the pastilles are placed therein by hand, being held in position by countersunk recesses and small pins. When the mould is filled, the molten lead pump is again brought into service, and the result is the framed negative in chloride form. The superfluous lead is then scraped off and it is sent to the reducing room where it is placed between sheets of zinc in an electrolyte chloride of zinc, thereby eliminating the chlorine from the chloride, and reducing the pastille to a very porous, crystalline mass of spongy lead, the crystals of which lie transversely to the plane of the plate and are beautifully pronounced, being plainly seen by the naked eye. After being washed, the plates are placed in tanks as cathodes to the current for several hours to insure the entire elimination of the chlorine, when they are taken out for shipment as finished negatives.

This interesting plant was installed by the Electric Storage Battery Company, of Philadelphia, and this comprehensive description of it was made possible through the valued co-operation of Messrs. C. O. Poole, L. D. Heitzroth, and R. G. Manifold, superintendent, assistant superintendent, and chief draughtsman, respectively, of the San Francisco Gas and Electric Company.

The principal features of the storage battery plant in the San Francisco Edison station are conveniently presented in the following table:

ENGINEERING DATA.

BOOSTER.

Capacity of motor	100 kw.
Capacity of generators	50 kw.
Number of generators	2
Applied voltage	240
Delivered voltage	50
Ampere capacity of generator armatures	1000

STORAGE BATTERIES.

Number of sets	2
Number of cells per set	75
Number of end cells	19
Plate dimensions	15½x32 in.
Containing cell	39½x46½x18 in.
Lining of containing cell	4-1b. lead
Number of positive plates	25
Number of negative plates	26
Number buttons in positive plate.	531
Number buttons in negative plate.	512
Type of positive	Manchester
Type of negative	Chloride
Weight of plates per cell	2000 lbs.
Weight of electrolyte per cell	850 lbs.
Total weight per cell	3334 lbs.
Maximum electromotive force	150 volts per set
Ampere efficiency	85 per cent.
Watt efficiency	70 per cent.
Sp. Gr. when fully charged	1.204°B.
Sp. Gr. when discharged	1.160°B.
Improves station efficiency	Materially
Improves load factor	About 5 per c'nt.

Capacity varies with discharge rate according to the following table:

Disch'rge in Amperes.	Capacity Amp. Hours.	Disch'rge in Amperes.	C'p'city Amp. Hours.
700	7000	2200	4680
800	6825	2300	4550
900	6650	2400	4430
1000	6500	2500	4310
1100	6325	2600	4200
1200	6160	2700	4090
1300	6000	2800	3980
1400	5850	2900	3875
1500	5680	3000	3780
1600	5525	3 00	3700
1700	5370	3200	3630
1800	5225	3300	3570
1900	5080	3400	3530
2 00	4950	3500	3500
2100	4800		

"Miners interested in electrical power will find this article well worth preserving," is the comment made by *The Mining and Metallurgical Journal* after reprinting the introduction of the serial now running in these columns on "Electricity in Mining."

---

* "The Electrical Engineer," (N. Y.) Vol. XXV, No. 521, page 443.

Transmission

POLYPHASE INDUCTION MOTORS.

ALTERNATING current motors, although developed and perfected much later than direct current motors, were soon recognized to possess such great practical advantages that they have by rapid strides largely supplanted the latter in many important applications. They have, in fact, done more; being advantageously used in places where electric power could not be previously employed by reason of some of the inherent characteristics of direct current apparatus.

Alternating current apparatus, owing to the field which it originally occupied, was for a long time looked upon by many as applicable only to the transmission of power over long distances. The extreme simplicity and flexibility of the alternating system, however, added to the attractions of the polyphase motor, have led to the use of polyphase apparatus for the distribution of power in factories, mills, mines, and other industrial establishments where the distances are comparatively short. A large factor in the present popularity of alternating current power is due to the high state of perfection to which the improved polyphase motors have been brought; yet despite their practically exclusive use on all power transmissions, a knowledge of their mode of construction and principles of operation are not commonly understood. To give needed information on these points may best be done by describing distinctive forms of apparatus, for which the type "C" motor of the Tesla polyphase system, as brought out by the Westinghouse Electric and Manufacturing Company, is first selected for illustration and description. Tesla polyphase induction motors have two main elements; viz.: the primary, which is directly magnetized by the currents supplied from the line circuits; and the secondary, in which low potential currents are induced by the action of the primary. The windings of the primary are so arranged that when supplied with alternating currents differing in phase; *i. e.*, polyphase currents, a rotating magnet field is produced. This field acts upon the secondary winding and induces currents therein. Rotation is produced by the action between the secondary currents and the rotating field of the primary. The principle upon which motors of this class operate was discovered by Mr. Nikola Tesla, whence their name.

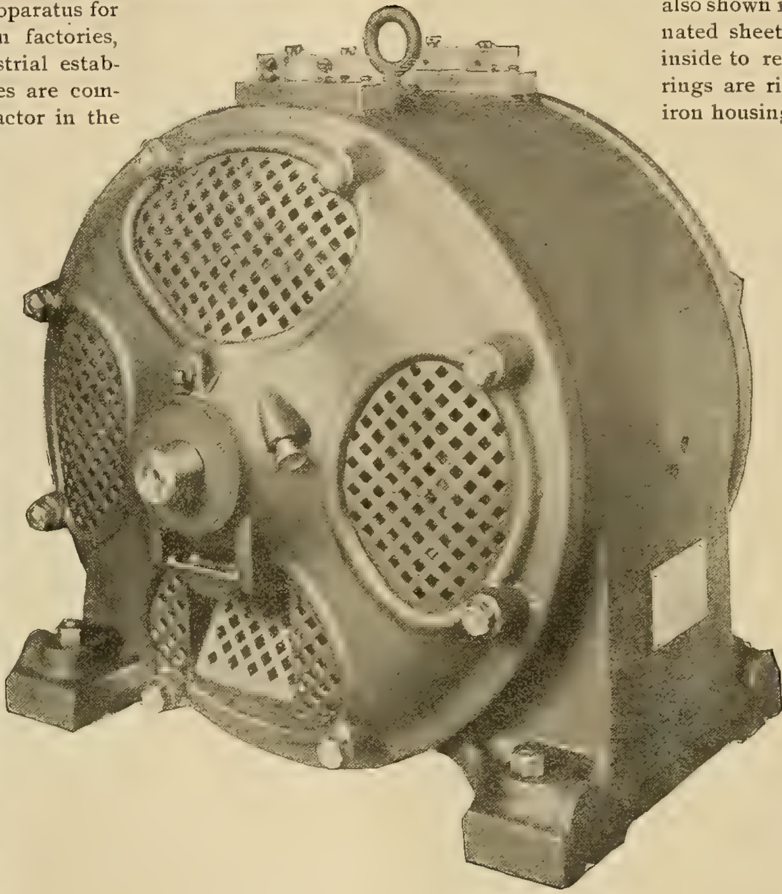


Fig. 1.—A TESLA INDUCTION MOTOR COMPLETE.

The revolving element of an induction motor may be either the primary or the secondary. In the motors described herein, the primary is stationary and the secondary revolves; hence, for purposes of comparison, the primary may be regarded as corresponding to the field magnets, and the secondary as corresponding to the armature of a direct current motor.

The form of the motor is shown in the accompanying illustrations, among which is that of a complete machine as shown in figure 1. It will be noted from the illustrations, that from a mechanical standpoint the induction motor is reduced to the simplest possible elements; *i. e.*, a stationary part, permanently connected to the main circuits, and a rotating part having no electrical connection with any other portion, and absolutely no electrical contacts or adjustments; in fact, no sliding or working friction except that of the shaft in the journals. It will therefore be observed that as a piece of moving machinery this type of motor is designed and built to operate for long periods of time with but a very small amount of cleaning and an occasional renewal of oil.

The hollow cylindrical frame of cast iron shown in figure 2, in which the primary is mounted, forms a base for the machine and also supports the two brackets carrying the self-oiling bearings. Ordinarily, perforated iron plates fitted into these brackets protect the rotating element and permit excellent ventilation, but they may be replaced by solid plates when it is desired to make the motor absolutely dust-proof. It will be noted that the housing completely encloses the primary and secondary elements, and protects them from any external damage. The primary element, also shown in figure 2, is built up of laminated sheet iron rings, slotted on the inside to receive the conductors. These rings are rigidly supported by the cast iron housing which encloses the primary. The conductors are machine wound coils, which are thoroughly insulated before being placed on the core. The secondary, which is shown in figure 3, is built up of laminated steel discs, made of a high grade of metal, mounted upon an open spider, and carrying in slots around the periphery the rectangular copper bars of the winding. The construction is such that the conductors cannot be thrown out by centrifugal force, the whole secondary being extremely simple, rigid and durable. Its conductors are all purposely short circuited, therefore it is evident that no accidental short circuit can possibly occur that will cause injury to the windings, and the danger of interruption to service from this cause, always a menace in direct current apparatus, is absolutely eliminated. The construction is also practically indestructible from heating, raising of coils, or mechanical injury in handling. This is undoubtedly the simplest and most durable form of secondary ever devised. Moreover, the end brackets may be bolted to the frame in any one of four different positions, so that the oil chambers in the brackets will be in the proper position whether the frame is bolted to the floor, the wall, the ceiling, or at a forty-five degree angle.

The type "C" motor is made with a variable speed for cranes, elevators, hoists, and similar classes of work, the variable speed motor being especially designed to give a proper speed curve, and is supplied with suitable regulating devices when necessary.

The power factor of an induction motor is found by dividing the real horse-power applied to the motor, by the apparent applied horse-power.

The energy supplied to a direct current motor is found by multiplying the current by the voltage; but in the case of an alternating induction motor, this product, designated the "apparent' energy, is greater than the real energy on account of the fact that the current in such large motors "lags" behind the electromotive force, and hence the useful effect is less than would be the case if the current and electromotive force were coincident in phase. The current, however, exerts its full heating effect upon the conductors, and the excess current causes a corresponding drop of potential in the circuit. It is therefore desirable to reduce the lag as much as possible; *i. e.*, to bring the real and apparent energies to coincide as near as we can. If it were possible to entirely eliminate the lag, the real and apparent horse-power would be equal, and the power factor would be 100. Special attention has been given to this matter in the designing of these machines, with the result that their power factors are very high.

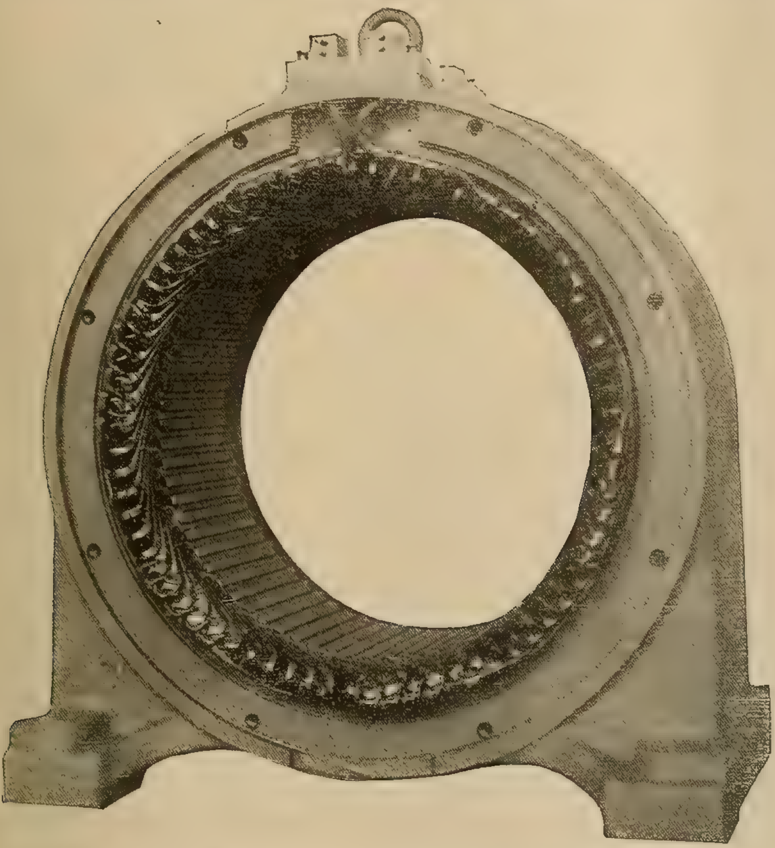


Fig. 2.—PRIMARY, WITH WINDING COMPLETE.

The designs and principles governing the construction of the type "C" motor are fortunately favorable to a particularly attractive feature; *i. e.*, the maintaining of a high and almost constant efficiency from full load to one-half load. Under the conditions which prevail in a very large proportion of electric motor service, the motors are operated much of the time at considerably less than their full rated capacities. With the type "C" motor, therefore, by maintaining a constant efficiency, there can be secured to the user an all day or average efficiency very much above that heretofore possible, with either direct or alternating current motors. The variation of speed between no load and full load is small, being less than that found in direct current motor practice.

A polyphase induction motor may be started by connecting it directly to the circuit with an ordinary switch, and small motors are so started in practice. The larger motors, however, are started on a reduced voltage, the full electromotive force of the circuit not being applied until the motors have reached a considerable speed.

In the Westinghouse system, the low electromotive force is ordinarily obtained by the auto-starter, shown on page 37, and which consists of a double throw switch mounted on a cast-iron box in which are two auto-converters. When the switch is closed in the position shown in the cut, the auto-converters are connected across the circuits and deliver a low electromotive force to the motor, but when the switch is thrown in the opposite direction the auto-converters are cut out and the motor is connected directly to the circuit. Three or four wires are connected directly to the auto-starter, and the same number of wires connect the auto-starter to the motor. The auto-converters are arranged with loops so that one of several voltages may be applied for starting, thus adjusting the torque for the work the motor has to do. Thus a motor operating a machine having great inertia may be made to give a correspondingly strong starting torque, or one driving a light device may be adjusted for extremely light starting torque with a corresponding reduction of current.

On two-phase circuits in which there are four wires, different electromotive forces exist between the different pairs of wires, and in some cases this affords a simple way of obtaining a low electromotive force for starting. A simple double throw switch is required, by which the low electromotive force for starting is obtained by one connection, and the full electromotive force for running by throwing the switch to the opposite position.

When it is necessary to install motors in a grain elevator, a woolen mill, a mine, or in any place exposed to inflammable gases or floating particles, or not easily accessible, the starting devices may be located at a convenient point more or less remote from the motor, thus eliminating all danger from fire due to possible sparks.

WIRELESS TELEGRAPHY IN COMMERCIAL SERVICE.

MARCONI'S system of wireless telegraphy was first put to test in actual commercial service during the week ending July 23d last when, according to the London *Electrical Engineer*, the Dublin *Daily Mail* and *Evening Express* concluded a most successful series of experiments consisting in the transmission of descriptions of yacht races sailed under the rules of the Royal Alfred Yacht Club regatta. The wireless messages were sent from distances varying from five to ten miles, and were published in successive editions of the evening paper. Not an interruption occurred; the instruments worked splendidly, and not a single message had to be repeated. Signor Marconi was the sending operator, being located in the cabin of a tug which accompanied the regatta, and the messages were received at the land station in Kingstown, Ireland. A great many representatives of the various telegraph and cable companies were present and followed Signor Marconi's experiment with marked attention and interest.

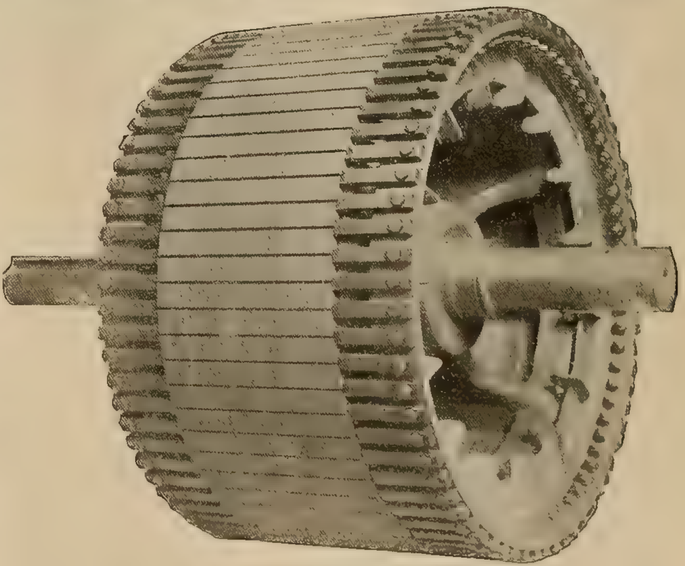


FIG. 3.—SECONDARY COMPLETE, SHOWING COPPER BARS CONNECTED TO END RINGS.

Personal

Mr. R. S. Masson, electrical engineer for the San Francisco office of the Westinghouse Electric and Manufacturing Company, who has become prominent in the electrical affairs of the Pacific Coast during the past two years, was born on a farm near Hammondsport, N. Y., in, as he facetiously expresses it, "1870, A. D." At school and college he was a close student, graduating with honors from the Lehigh University, at South Bethlehem, Pa., in the class of 1892 with the degree of electrical engineer. Almost immediately thereafter, Mr. Masson started at work with the Field Engineering Company of New York City—a concern which was, at that time, most prominent in the electrical construction and engineering business—being engaged on work for the Buffalo Railway Company, of Buffalo, N. Y. The dissolution of the Field Engineering Company followed not long thereafter, however, but, having proved his value to the Buffalo Railway Company, Mr. Masson's services were retained as general construction engineer until 1894, when, realizing the advantages that would follow from becoming identified with a large electrical manufacturing company, he resigned his position to enter the employ of the Westinghouse Electric and Manufacturing Company at Pittsburg. There he spent about a year in practically all of the different branches of the great establishment, which resulted soon in his being placed in charge of the night force of the testing department. It was in this position that some most valuable experience was gained, so that when the great initial installation of three 5000 horse power generators was installed at Niagara Falls in 1895, Mr. Masson accepted the position of switchboard operator for the Niagara Falls Power Company. After these three mammoth generators had been in successful operation for several months, however, Mr. Masson returned to the employ of the Westinghouse Company at Pittsburg, where he spent another winter in experimental testing in the shops.

RAYMOND STANISLAUS MASSON.

Up to this time the San Francisco office of the Westinghouse company had been practically without the services of an electrical engineer who was thoroughly experienced in polyphase work, and at the request of Mr. W. S. Heger, manager of the San Francisco office, Mr. Masson was chosen as being well qualified for executing the responsibilities of the position. This he has done to the eminent satisfaction of all concerned, and it is not venturesome to predict that he will long continue to be a material factor in the further development of the electrical resources of the West.

Mr. Wm. S. Brayton, of the New York office of the General Electric Company, was married May 3d last, to Miss Alice Wait of Ithaca. Mr. Brayton is a graduate of Cornell and passed through the works at Schenectady before assuming his duties at the New York office. He is a favorite among all his associates, who testified their appreciation by presenting him with a handsome souvenir of their esteem. Congratulations are extended to the happy couple on entering their new career.

Lieut. W. Stuart-Smith, U. S. N., has been detached from Mare Island Navy Yard and ordered to Seattle, Wash., as inspector of machinery of the United States torpedo boat "Rowan." After the war is over, he will probably return to San Francisco to the practice of his profession of consulting and supervising mechanical and electrical engineer.

Mr. C. F. Scott, chief electrician of the Westinghouse Electric and Manufacturing Company, and than whom no man has contributed more toward the development and perfection of electric power transmission, is making a tour of the principal places of electrical interest on the Coast.

Mr. S. A. Duncan, past president of the National Electric Light Association and now special agent of the Postal Telegraph Company, was in San Francisco during the first week of August.

Dr. N. S. Keith has completed the installation of a forty-ton mill at Cyanide, Colo., for the extraction of gold and silver by the Keith electro-cyanide process, and has opened an office at 62 Nevada block, San Francisco, as a mining, metallurgical and electrical engineer.

Mr. T. H. Macdonald, late chief engineer of the steam equipment of the San Francisco Gas and Electric Company, and more recently of the Hawaiian Commercial Company at Maui, has been appointed superintendent of the Honolulu Iron Works at Honolulu, H. I.

Mr. H. C. Wybro has turned over the Pacific Coast agency for the Walker Company, of Cleveland, Ohio, to the Wybro-Hendy Company, of San Francisco, and of which Mr. Wybro is president and manager, and Mr. S. J. Hendy secretary and treasurer.

Mr. C. E. Freeman, of the Department of Electrical Engineering of the Armour Institute of Technology, of Chicago, was a recent visitor to San Francisco, where he stopped for a few days while visiting the points of electrical interest on the Coast.

Mr. J. W. Brooks, late of the Brooks-Follis Electric Corporation, has been appointed western manager of the Fostoria Incandescent Lamp Company and of the Crouse-Tremain Carbon Company, with offices in the Monadnock block, Chicago.

Mr. Wynn Meredith has resigned from the position of electrical engineer of the firm of Hasson & Hunt, and has joined Mr. A. M. Hunt, late of the same firm, and who is now in Alaska as chief engineer of the Alaska Commercial Company.

Dr. F. A. C. Perrine, electrical engineer of the Standard Electrical Company of California, is now in the East on business connected with the proposed Blue Lakes-San Francisco transmission. He is expected to return in September.

Mr. Alexander G. McAdie, late local forecast official of the San Francisco station of the United States Weather Bureau, has been advanced to the New Orleans station of the Weather Bureau, whither he has gone to assume charge.

Mr. W. A. Burkholder has completed the installation of the telpherage electric freight tramway over the Chilkoot pass, for the Dyea and Klondike Transportation Company, and has returned to San Francisco.

Mr. C. R. Lloyd has retired from the Pacific Coast agency of the Fort Wayne Electric Corporation, which is now held by Mr. F. N. Delanoy, with Mr. W. W. Briggs as electrical engineer.

Mr. Allan H. Babcock has become identified with the Standard Electric Company of California in the capacity of electrical assistant to Dr. F. A. C. Perrine, its engineer-in-chief.

Mr. M. L. Osler, the well known salesman of the Washburn & Moen Manufacturing Company, has been placed in charge of the Los Angeles office of that prominent concern.

Mr. E. L. Brayton, secretary and treasurer of the Pelton Water Wheel Company, is on a business trip to the New York and London offices of the Pelton company.

STARTING NON-SYNCHRONOUS MOTORS.

WITH a suitable resistance in the armature circuit, a single-phase motor can be started by giving a very small initial velocity to the armature, such in fact as can be given by a pull on the belt by hand, says Sig. R. Arno in an Italian electrical contemporary. Once started, the resistance can be gradually cut out. This method of starting does away with the necessity of two windings on the inductor and means for producing a difference of phase between the two.

The author, in his second paper, describes a method of giving the initial starting-pull to the motor by electrical means only. The method is to produce a dissymmetry in the armature at the moment of starting by opening the circuit of one of its windings. Then, provided the armature is not at a dead-point, it will rotate through a portion of a turn, and, if the circuit be then closed, this rotation provides a sufficient impulse to enable the motor to get up speed. Supposing the armature to have a three-phase winding, a three-arm resistance-switch is inserted in the three circuits, the full resistance being the best starting resistance mentioned above. Two circuits are closed through the resistances; the third is brought to one pole of a two pole switch, the other pole of which is in the field circuit. The switch is so arranged as to first close only the field circuit, thus giving an initial rotation to the armature; a further movement of the switch closes the armature circuit and enables the motor to get up speed. The best conditions for starting are obtained by cutting all outside resistance out of the armature circuit, putting it in immediately the circuits are closed. The armature can be moved from a position of dead-point by means of a switch in one of the other circuits; if the double-pole switch be closed, leaving this switch open, the armature will rotate to a dead-point corresponding to this position of dissymmetry. On breaking the circuit and closing the single-pole switch, the position of dissymmetry is changed, and the motor is no longer at a dead-point. The direction in which the motor starts is determined by the circuit in which the single-pole switch is placed.

ACCUMULATOR VARIATIONS AND ACID STRENGTH.

LIEBENOW'S theory, which regards the accumulator as a reversible cell, is contended by F. Dolezalek, in a German electrical contemporary, to be the only one which can be consistently maintained, and with which the behavior of the cell is in agreement. The differences in the electromotive force of accumulators with different concentrations of acid are shown to be in excellent accordance with the values calculated by two independent methods based upon thermodynamical considerations. The efficiency of the accumulator amounts on the average to seventy-five to eighty-five per cent., although ninety-four to ninety-seven per cent. of the current used in charging is recovered on discharging. This is caused by the difference in electromotive force during charging and discharging, which has led to the belief that the action is only partially reversible. This difference is attributed to mechanical hindrances to the equalization of acid concentration in the neighborhood of the electrodes, whereby the accumulator behaves during charging as if filled with a stronger acid, and during discharge as if filled with a weaker acid, than is really the case. It is calculated that the accumulator should work with maximum efficiency when filled with acid of maximum conductivity (30.4 per cent. H_2SO_4). Here also, experiment is in close agreement with theory.

LIGHTER THAN HYDROGEN.

Prof. Nasini, of Padua, has communicated to the French Academy the result of his investigations with Signori Anderlini and Salvadori, into the gases issuing from the earth in volcanic districts, among which they find coronium, hitherto known hypothetically only as a constituent of the sun. The discovery, which in conformity of the results of spectroscopic examinations of the sun, adds another element, and one which seems to be far ligher than hydrogen.

ARC LAMPS AS TELEPHONES.

The flame of an arc lamp is very sensitive to slight variations of the current, such as those produced by induction from a neighboring intermittent current. When the neighboring circuit contains a microphone, the arc may be made to reproduce various sounds and noises communicated to the latter. It reproduces them with great fidelity. Conversely, a sound impinging upon the arc produces in it changes of density, which give rise to changes of resistance and modifications of the current, which may in turn excite a telephone. The arc thus plays the part of a telephone receiver and transmitter.—*Science Abstracts.*

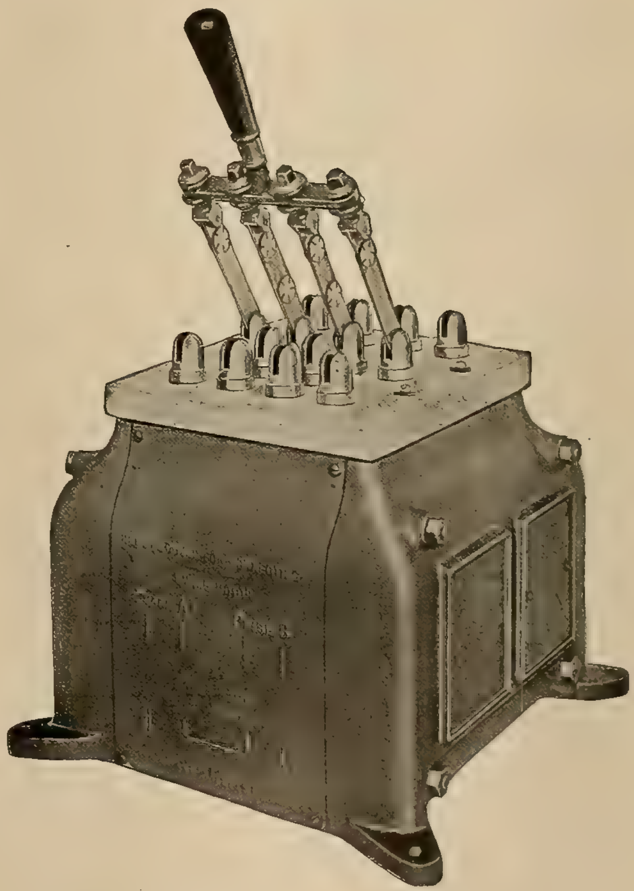


FIG. 4.—AN AUTO-STARTING DEVICE.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity, Gas, and Power.

Official Organ of the Pacific Coast Electric Transmission Association.

Subscription invariably payable in advance. Terms—Domestic, One Dollar per Year; Foreign, Two Dollars per Year. The trade supplied by the San Francisco News Company. Advertising rates furnished on application.

GEO. P. LOW, : : : Editor and Proprietor

PUBLICATION OFFICE:
320 CALIFORNIA STREET,
ROOM 14.

Address all communications to
Editorial rooms, 427 TENTH AVE.
Telephone, "Steiner 623."

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME VI AUGUST, 1898 NUMBER 2

EDITORIAL.

"INSULATORS," AS VIEWED BY A CONTEMPORARY.

Much surprise, not alloyed with approval, will be expressed by electric transmission interests upon reading the leading editorial in *Electricity*, (N. Y.) for July 27th, which contains references to glass insulators for use on high tension transmission lines, the opinions given being far from substantiated by actual practice. Referring to "high tension transmission, or where a line transmits current at a pressure of from ten thousand to twenty thousand volts," our contemporary says:

> Glass or porcelain has to be relied upon almost entirely, although in some cases pottery or stoneware insulators have been used in foreign countries. None of these substances are by any means ideal, and especially glass, which is too brittle and very apt to be broken under a jerk or strain.

Then, further on, appears the equally groundless statement:

> Owing to the brittleness of glass, so far on most of the very high tension transmission lines in this country, porcelain is used.

The forty thousand-volt transmission between Provo and Mercur, in Utah, and which is the highest potential used for transmission purposes in the world, uses glass exclusively on its thirty-two-mile line; the San Joaquin Electric Company, whose thirty-five-mile line was originally equipped with porcelain, has built its thirty-three-mile extension to Hanford with glass insulators and has announced its intention to substitute glass for porcelain insulators on the line between the power house and Fresno as soon as the line potential is raised from ten thousand to nineteen thousand volts for the operation of the Hanford extension. The Yuba-Marysville transmission uses glass exclusively on its 16,500-volt transmission; and, in brief, of all the high tension electric power transmissions on the Pacific Coast, operating or projected, the only noteworthy exception to the broad statement that glass insulators are used wholly or in part—the latter being for new extensions or renewing porcelain insulators that have broken down—is in the 33,000-volt transmission line of the Southern California Power Company, now under construction. Concerning the adoption of porcelain insulators on this line, Mr. O. H. Ensign, electrical engineer for the Southern California Power Company, remarked before the recent meeting of the Pacific Coast Electric Transmission Association, that at the time the Southern California Power Company was trying to decide on the type of insulator it would use, he could not, to use his own words, find a glass insulator "that was large enough to stand the potential without the distance from the tie wire to the pin being too near the sparking distance of the potential used, so we were rather forced to the porcelain insulator." That the trouble Mr. Ensign referred to is now overcome is evidenced in the use of glass in the Provo-Mercur transmission, which has been running since early in March last without trouble. Without doubt, the days of porcelain insulators for use on extremely high voltage lines, are numbered.

While, so far as we know, it is yet to be demonstrated that static electricity exerts any appreciable influence on the temperature of transmission insulators toward the dissipation of moisture that may accumulate thereon, it is well understood that the presence of high tension current on the line tends to preserve its insulation resistance. Witness, for instance, the difficulty that attends the starting of the Provo-Mercur transmission during a rainstorm, (which occasions repeated blow-outs of the fuses before the line can be held) while if the line is already in operation, no rainstorm, however severe, affects it in any appreciable way. Nevertheless, our contemporary's utterances on this point are interesting and are here reprinted:

> On all telegraph lines where glass or porcelain insulators are used there is, as is well known, always more or less leakage due to the insulator becoming damp through the condensation of the moisture of the air. In the case of a high potential transmission line, however, this accumulation of dampness on an insulator does not, as would naturally be inferred, cause a leakage providing the insulator is properly shaped. This is due to the fact that as soon as an insulator on such a line becomes moist and leakage tends to begin, static electricity is immediately formed, which heats the surface of the insulator and preserves comparatively large dry areas between the streams that run down from the falling drops.
>
> This remarkable action of the drying of porcelain insulators by static electricity is probably one of the most valuable discoveries so far noted in the transmission of high potential currents.

SISTER INDUSTRIES, YET ESTRANGED.

No one knows whether the dreamed of Utopia, wherein gas and electric industries will so far overcome their cat-and-dog propensities as to make common cause for the advancement of the industry of artificial illumination will ever be realized, for at times it seems as if those who have hoped for the consummation of this desirable conciliation are at least over sanguine. It must be confessed that the haughty *one* extends but little encouragement to the aspiring *other*, and it is ultra-conservatism thrice personified which accepts evidences of friendship and good will—further, if you please, the substantial testimonials of ripened cordiality—with lukewarmness, or even condescension. Gas and electricity, like pneumatics and electrics, are sister sciences, and protracted strife between them is unnatural and unwarranted. Together they form the two factors constituting the magnificent industry of artificial illumination; apart, the industry is divided against itself and will never attain the pinnacle of perfection, which, combined, may be easily scaled. United they present a solid front, impregnable alike to internal dissensions or foreign assaults; divided they are ever torn with civil strife and the fullest measure of prosperity is impossible.

Competition to the death, as is being waged in many localities between gas and electric industries, is a senseless and obstinate struggle which throws the greatest possible blight upon any investment, however promising it may appear.

THE INFLUENCING OF STOCK VALUES.

The many depreciations that have been brought about in the market value of illuminating stocks at different periods the country over by reason of announcements of so-called "revolutionizing inventions," bears witness to the fact that as a rule, the opinions which influence stock holders and the financial public in general, are in the main, of a very superficial nature. Too often, indeed, are mere newspaper publications concerning technical matters accepted as gospel truth, even when in bald contradiction to exact scientific knowledge—and stocks slump at their echo as the colt shies at the passing litter. Nevertheless, he is wise who recognizes the menace to which the value of all corporate shares are exposed from changes which may be wrought by the inventor's magic, and he is a veritable dotard who locks himself secure in the belief that the science of electric lighting is preserved wtth immunity from assault along this cause, by reason of its present prosperity. When the truth, ofttimes stranger than fiction, is realized that the efficiency of the incandescent lamp as a medium of rendering illumination from the energy of the coal pile or the water power, is so ridiculously low that the electrical scientist blushes to name it, it is folly to contend that further advance along the line of its development is impossible, or that invention will ever cease its endeavors to improve the present condition.

While the utmost caution must be exercised at all times in taking up the consideration of new inventions, a manifestation of wisdom is shown in giving due attention to each which follows the trend of original research. The latest announcement on the part of the lay press that comes under this category is the publication in a recent issue of the *New York Times* of an article attributed to Dr. Johannes Horowitz, of Vienna, in discussing a new type of incandescent electric lamp invented by Prof. Walter Nernst, and the patent rights for which, it is averred, have been sold to a Berlin syndicate for $1,500,000. Dr. Horowitz states that despite this sale, no practical or commercial use can be made of the discovery—but the why-not is not given.

From the description, it appears that in the Nernst lamp, the carbon filament is entirely done away with, a filament of magnesia or other metallic oxide that has been subjected to an intense heat, being substituted therefor. But to quote Dr. Horrowitz' own words:

> When in a conductive state such bodies allow the current to pass, and through it they are made to glow intensely by reason of the great light-emissive power possessed by the substances. Nernst's incandescent bodies have proved perfectly stable at the enormous temperature (more than 300 degrees centigrade) which is produced by electricity when these bodies are made to glow, a temperature at which platinum wire and carbon filaments become volatile and waste away. This renders it possible to produce a high degree of light intensity by means of a comparatively weak electric current, and the experiments already made have proved that we can reckon on an economy far surpassing that of the carbon filaments hitherto used. Unlike the ordinary incandescent lamp, the Nernst lamp will not require a vacuum, but will shine in the free air; indeed, the admission of air has proved to be advantageous, probably because the chemical changes brought about by the enormous heat, and especially the reduction of the incandescent substance, is compensated when oxygen is taken from the air as a substitute.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

PICTURE TRANSMISSION BY WIRE.

Szczepanik, a young Polish school teacher, claims to have invented a telelectroscope, an apparatus for the transmission of scenes and pictures over a wire, and the details of his invention, minus some of its vital features, appear in *The Electrical Engineer* (N. Y.) for July 7th. It is a combination of lenses, reflectors, and presumably small selenium cells in constant rotation, each reflector being in a state of rapid vibration. The motions of the reflectors of the transmitting and receiving systems are, moreover, synchronical. It is said that according to the testimony of eye-witnesses, the transmission of pictures is perfect, and that the central committee of the Paris Exposition of 1900, where the invention will be shown to the public for the first time, has guaranteed the young inventor 3,000,000 francs. A telephone is usually connected with the telelectroscope to make conversation possible simultaneously with sight.

The perfection and adoption of the telelectroscope plays into the hands of the telephone companies admirably, but the arrival of the time when every telephone subscriber can pay four dollars per month (invariably in advance according to the terms of his contract) for the privilege of having a telelectroscope attached to his 'phone, will not, in all probability, be an unmixed blessing. True, he can call up his friend Jimson and each can read the other's morning paper, (unless they happen to be on a party line and subject to a time limit) but this will be of no especial advantage when newspaper subscriptions are so cheap. Territorial tolls are high, too, which prohibits the interchange of morning paper courtesies between Tompkins, of Petaluma, and Snodgrass, his friend, in Milpitas. But to look at the brighter side: The telephone company could develop a source of princely revenue by arranging the telelectroscope so that on placing the coveted nickel (or mayhap quarter) in the slot and pushing the button "way down," the features and curl papers of the sweet-voiced telephone girl could be made to appear in all their embarrassed glory upon the diaphragm of the contrivance. Then the family physician—what a boon! Imagine him ordering you to step to the telelectroscope and "show me the whites of your eyes," or the inevitable: "stick out your tongue."

All that glitters is not gold, saith the proverb, and the shimmer of the telelectroscope will be unalluring to many, who will regard its adoption askance, for even in the inventor's Polish name, one sees a premonition of breakers ahead.

"SCIENCE ABSTRACTS."

Of all attempts that have been made to index technical literature, none appears to have been more successful or satisfactory than that of the Institution of Electrical Engineers, and the Physical Society, both of London, as together presented in *Science Abstracts*, a handy monthly magazine which is a trifle larger in size than *Electrical Engineering* of Chicago.

Science Abstracts is ideal in every respect, or at least it will be so if the same care is given to the arrangement of the index for the completed annual volume as has been bestowed upon the monthly issues thus far published. Dealing only with physics and electrical engineering, it is not burdened with a multitude of abstracts along lines wherein the electrician is but little, if at all, interested. Physics and electrics are so closely related as to be often all but indistinguishable, yet in *Science Abstracts* the arrangements are such that the subjects are clearly separated, although jointly presented. Moreover, the abstracts are full, clear, and comprehensive, as though every word was individually weighed; they are not "boiled down" to disjointed skeletons, nor do they contain aught beyond the very gists of the articles. Each abstractor, of whom there are more than fifty, signs his writings with his initials, thus identifying the editorial labors and fixing the responsibility for such. It is both tedious and laborious to search through abstracts made weekly when in quest of the substance of a particular article, and those which appear monthly are far more serviceable in this respect. But where each monthly abstract is conscientiously indexed and arranged to be available for binding into yearly volumes so as to still preserve intact its features of ready reference, it becomes of the utmost value. It is this that *Science Abstracts* accomplishes more effectually than any other similar work yet attempted.

Mining

ELECTRICITY IN MINING.—IV.

An electric tunnel excavating machine is described in "Engineering" (London), April 22, 1898, page 486. This apparatus removes the earth and the rock, and deposits it upon the attached car. In operation the machine is traveled up to the face and excavates all that can be reached for a distance of eighteen inches to two feet in front of the shield, the portion which the machine cannot reach being the top and the sides. The machine is then run back ten or twelve feet clear of the face and the shield pumped forward, the cutting edge bringing down the remaining portion of the earth. No difficulty has ever been met with in cutting this part of the face, and of course, there is a material engineering advantage in getting a clean cut and insuring that no cavities are left outside the shield. The face being now clear the iron lining is erected and bolted up, and the excavator brought forward for a fresh cut. The usual small boulders are taken out by the machine without difficulty. When large boulders are reached, the earth is cleared out all round by the machine, and the boulder removed by hand.

A fuse is inserted in the lead to the motor so that in the event of too heavy a feed being given no damage will result to the gear. So far no breakdowns have taken place with the exception of the breakage of some buckets, and the excavator has given great satisfaction at work. Being an experiment it was not built so large or heavy as could be employed, and a greater saving would result by the use of a larger machine. As it is, the saving over hand labor is very considerable; the average advance is three twenty-inch rings per shift of ten hours, the number of men at the face, including the engineer, being eight.

The above apparatus, though originally designed for street undesground excavation, is applicable to mining in soft seams, and requires no special intricacies of design, being in effect an electric shovel.

In the operation of drilling, compressed air, steam, water and electricity have each had their day and place, but the electric system is destined to become popular. By its use, holes difficult or impossible of being otherwise reached, except by hand labor, are drilled with ease and rapidity. The motor may be mounted on an iron truck, with the necessary starting resistance, speed reducing gear and switch. The machines are usually shunt-wound, over-compounded, and about two horse-power in capacity. The supply voltage is about 100, and the current four to five amperes The coupling between the motor and the drill may be either an ordinary flexible shaft, or a telescopic shaft furnished with universal couplings. The ratio of reduction of speed may be readily altered by the substitution of a different set of gear wheels at the motor. Thus, by the provision of change wheels, is obtained a large range in the size of the holes which the machine can drill. The motor is supported on trunnions giving a universal motion.

The performance of these machines is most satisfactory. By their use one man and a boy have drilled ⅝-inch tapping holes 1¼ inches deep in tough cast steel at the average rate of more than 100 per day of eight hours; these figures taken from the weekly record sheet, including all setting up, grinding tools, etc.

HISTORICAL.

The superceding of the old pick and shovel methods in coal mining marked the beginning of the application of electric power to mining operations. It was in the coal fields of western Pennsylvania that electrical apparatus was introduced in mines, and the rapid progress made since that time has extended its application into the fields of placer, crusher, and all systems of dealing with the ores of the precious metals, as well as in electrolytic work and refining, and in the modern cyanide process.

An early example of a mining machine operated by an electric motor was in the first pool in the Monongahela coal fields, in 1889. The machine was connected to a Tesla motor, and ran so successfully that a similar installation was made in the following year. In 1890 the Armstrong mine was equipped. The experience gained even in these early installations, proved that electricity was, of all motive powers, the best adapted to such service.

The next class of work to receive the benefit of electrical operation was that of iron mining. In 1890 the Ashland mine of Ironwood, Mich., was supplied with a complete electric lighting plant of 600 lights capacity. This mine is 720 feet deep, and consists of eight layers, connected by ladders, some of which are nearly 100 feet in length. Fully 2000 miners were employed at the time the mine was equipped, and the extent of the system was only equalled by the engineering difficulties encountered in designing a lighting plant for the service. Dampness prevailed everywhere, and to secure perfect insulation every coil of wire was drawn through insulating paint. Four months were required to complete the undertaking, and when complete not the least trouble was experienced in the operation of the system. The generator station was located in the pump house, and the switchboard was constructed of such unique material as beaten boards of white and brown birchwood. In its time, this was considered an important installation and attracted much attention.

Another example of mine lighting, installed in the same year, was that of the Monongahela Mining company. This was a coal mine, and the possibility of using electrical apparatus in the presence of explosive gases was here demonstrated by the Westinghouse experts. The mine circuits were of 300 volts, and 100-volt lamps were used, three being connected in series across the mains.

The Shawmut coal mines, in the state of New York, were among those first to use motors for operating coal cutting machinery. Their first installation consisted of a thirty horse-power Westinghouse generator, and seven alternating current motors connected to mining machines.

With the remarkable advancements made in the transmission of power by polyphase systems, the mining industries of the West were deeply concerned. The first practical illustration of the possibilities in this direction was made by the Westinghouse company in the world famed Telluride mines, which, though hitherto unprofitable, were economically worked by the cheap power supplied through electrical transmission. Fuel, expensive and often unattainable at any price in the elevated mining camps of the Rockies, was done away with entirely, and the power of a neighboring waterfall was made the invaluable adjunct of a quartz crushing plant. Up to 1892, the longest distance of power transmission was three and one-half miles. In that year, a transmission of eight miles was proposed with some hesitancy, but it remained for the Westinghouse company to demonstrate by a successful example the possibility of transmission for fifteen miles. It was near Denver, that a turbine wheel was connected to a Westinghouse generator at the side of a permanent waterfall, and the current transmitted across the mountain to a motor at the mine, with a small percentage of loss and no difficulties in insulation.

The San Miguel Consolidated Gold Mining Company was the company in whose behalf the Telluride plant was installed. The altitude of the mines was 13,000 feet above sea level, and the cost of coal and power up to the time of the Telluride installation, made economical operation impossible. The Westinghouse polyphase system was adopted, and a 100 horse-power generator connected to a Pelton wheel was placed at a distance of three miles from the Gold King mine. A few weeks demonstrated the perfection of the system, and it was extended to all the mines of the company, two 800 horse-power generators being placed at the power plant, and motors and transformers being connected at suitable locations for the work of the various mines.

In June, 1896, one of the largest shipments of electrical apparatus ever made was sent from Pittsburgh to the Boston and Montana Consolidated Copper and Silver Mining Company, at Great Falls, Montana. The latter firm is one of the largest in the mining world, and ordered a complete electrical equipment. The work of the company was largely in the refining of copper and silver. This had been done in the past at large plants in the East, the cost of power in the mining districts being prohibitive. The Anaconda Mining Company had just demonstrated the utility of electric power in a similar class of work, and the former firm decided to follow its example. The turbines were located at Great Falls, Montana, and Westinghouse generators were direct-connected to them. The latter were the largest electrolytic generators that had been constructed up to that time. They were of 1200 kilowatts capacity, producing 5500 amperes at 220 volts. The entire auxiliary apparatus was ordered with the generators, and some idea of the amount of apparatus supplied may be obtained from the fact that eight freight cars were required to transport it from Pittsburg, and that the freight charges alone amounted to $8000.

The most striking step that has been made in advance in recent years, rests, as has been stated, in the introduction and perfection of electric mine locomotives. The Westinghouse and Baldwin companies, working in conjunction, have placed these in several of the important mines of the country, and they have never failed to give thorough satisfaction in combining simplicity and convenience of operation with low cost for the locomotive itself and for the power used. Among the coal mines recently supplied with such apparatus are the Shawmut, St. Mary's, Penna., the Stevens, Acme, W. Va., and the Crozer, Elkhorn, W. Va.

Where some other form of motive power, as compressed air, is already in use, electrical apparatus has often been found the most economical for the prime mover. In the Jumper mine, Tuolumne county, Cal., a combined compressor and electric plant is in operation. A Westinghouse generator, driven by a 250 horse-power Pelton wheel, furnishes the current.

The late exploitation of the cyanide process has given rise to a multitude of new phases of application of electric motors. The largest cyanide mill in the world, that of the Golden Gate, at Mercur, Utah, as described in the June number of The Journal of Electricity, is operated entirely by electric power, the transmission being from Provo, Utah, a distance of thirty-five miles, at a potential of 40,000 volts. The capacity of the mill is over 500 tons of ore per day, with apparatus which could be easily made to more than double that capacity. Transmission is three phase; distribution, at 220 volts, is two phase, and the motors are all of the induction class, aggregating 700 horse-power. The mill company buys the power from the proprietors of the generating station at $60 per horse-power per year, with a minimum consumption of 300 horse-power. At the time the Golden Gate mill was erected, some doubt was felt by the owners as to whether electrical machinery would be found adequate for the heavy work of the plant. It has turned out, however, that the electrical apparatus is the most satisfactory and reliable part of the entire equipment. If a crusher becomes clogged, it is usually the case that a belt or gear will break rather than the motor become stalled. Electric power in mining has come to be recognized as the direction of progress in mining engineering. The example of the Mercur plant is only one of many in which the introduction of electrical apparatus has greatly cheapened the cost of power.

ELECTROLYSIS IN COPPER REFINING.

ELECTROLYTIC processes for the production of refined copper have been developed very rapidly during the past three years, and at the present time, a very large proportion of all the refined copper is thus produced. The Westinghouse Electric and Manufacturing Company have installed a very large amount of apparatus for this class of service. One of the principal installations is at the refinery of the Anaconda Copper Company, Anaconda, Montana, where ten generators of 270 to 300 kilowatts capacity have been installed. Another very large installation is that of the Boston and Montana Consolidated Copper and Silver Mining Company, Great Falls, Montana, where two 810 kilowatt Westinghouse engine type generators are in service.

The latest comer in this field is the Raritan Copper Works of Perth Amboy, New Jersey, which is about to erect the largest copper refinery in the East, having contracted with the Westinghouse Electric and Manufacturing Company for three 600 kilowatt, 150-volt, engine type generators, 150 revolutions per minute, with a nine-section switchboard for electrolytic service, and the operation of two 75 kilowatt, 220-volt, engine type generators, which will be used for lighting and power service. The installation will be the most complete of its kind in the world.

RUBBER WILL NOT HOLD ACETYLENE.

According to a German photographic contemporary, a rubber bag will not hold acetylene gas. In half an hour there is a strong smell of escaping acetylene, and in three days the bag is empty. Thereafter the same bag is found to be perfectly impervious to air, so that the leakage of the acetylene is not due to holes, but depends on the nature of the material of which the bag is made.

Proceedings of the Second Annual Convention of the Pacific Coast Electric Transmission Association, Held at San Francisco, June 21, 1898.---Concluded.

(Continuation from page 17, of last issue.)

MR. ENSIGN: The Redlands generators operate at 2,500 volts, supplying Redlands and the Union Ice Company direct. At this time of year, when the Ice Company's load is the highest, the Redlands load will run up to 30 or 32 amperes per leg, and the ice plant, with both pumps running, will average 45 amperes per leg. The ammonia compressor is a double-cylinder pump, 16x30, with cranks set 90 degrees apart, which, with only one pump on, will run as high as 30 or 32 amperes. With this load we could never notice the slightest flickering of lights in Redlands, which may be due to the synchronous motor used. To show how an induction motor will act on a fluctuating load, I may say that in the city of Riverside, where they have a recording ammeter in each leg of the circuit for keeping a record of the power used by the city, there is a 30 h. p. induction motor, operating a planing mill, giving a constantly fluctuating load. When that motor is working under an average horsepower of 8 h. p., as shown by the watt meter on the motor, the fluctuation on the ammeter represents a range of over 100 h. p. An induction motor, working on reciprocating apparatus, will cause fluctuations in the current to be multiplied enormously. This is the way I account for the difference between Mr. Eastwood's experience and ours; for even when a check valve becomes stuck in one of these ammonia pumps, there is no flickering in the lights at Redlands.

MR. LIGHTHIPE: There is a great difference between the lifting of water and the pumping of gas, as the gas is compressible. I have always had trouble in pumping water, especially in mining pumps, with anything outside of the triple-plunger pump, probably on account of this long column of water, for every plunger, as it comes into action, has to change the speed of that column. Anything that is compressible, in the way of gas, will ease up the stroke.

MR. EASTWOOD: We have an ice plant of thirty tons capacity, operated by a 150 h. p. induction motor,—also a 50 h. p. induction motor and a 10 h. p. induction motor,—and we find no fluctuation whatever due to the ice plant, which runs twenty-four hours straight through.

MR. RIDLEY: It may be outside of the general trend of the discussion to talk about direct current, but I am rather inclined to bear out what Mr. Ensign says, that the fluctuation would come rather from the alternating current used than from any other cause. The Central Light and Power Company is operating a load that varies; a steady motor load of 150 amperes and a light load of 100, making 250, and it has the Sprague elevators running the load up to a thousand amperes, and we find no difficulty whatever in steadying our lights. We have no complaints from customers of fluctuation in light, and the only precaution that we have in any wise taken has been the diminishing of the fly-wheels of the engines and enlarging the steam ports; but I don't think we can get any better regulation than you could get from water power. The only point I would bring out is that I think this would show that the functions of the alternating current and also the influence of the line would possibly cause a great proportion of the fluctuation that is found in the plants which are operating with alternating machinery.

THE CHAIR: How do you reconcile that with Mr. Eastwood's statement that by using the same type of electric apparatus exactly, but upon different loads,—a compressible gas load and an incompressible water load,—that he finds the results very different indeed; one produces decided fluctuations in his lights and the other does not?

MR. RIDLEY: A compressible load will always save the fluctuation, naturally, but I consider that a Sprague elevator load is an *incompressible* load. [Laughter.]

MR. HUTTON: We are operating a compressor, located about a mile from the sub-station, which is driven by a 100 h. p. motor. Incandescent lights on the same circuit at the end of this line have considerable fluctuation when the compressor is working. It is a single-cylinder machine, but it does not affect the rest of the load outside of that one line.

GLASS OR PORCELAIN INSULATORS?

THE CHAIR: There is one ever-fruitful subject of discussion, and that is the insulator subject, and I have been asked to bring it up, and I should have done so had I not been asked, because I was curious to know from Mr. Eastwood why he substituted glass for porcelain insulators after having used porcelain for some time, and I will therefore call on him first to give us any suggestions that he may have to make from his very fruitful experience on the insulator question.

MR. EASTWOOD: In the matter of insulators, the Folsom-Sacramento plant and ourselves were really pioneers, and in the matter of extreme long distance transmission our plant at Fresno has always held the lead until a short time ago, and, in fact, we now again hold the lead in long distance transmission. When we started in we, of course, took the apparatus which was offered us by manufacturing companies, in the condition that it was then worked out. We have, on our thirty-five mile line, a general electric porcelain insulator which was furnished at that time to both the Folsom-Sacramento and the San Joaquin plants. Of course, in the construction of the line, the insulators were shipped out in barrels, not put through any test, teamed out on the line, and then put up without any particular inspection. The first six months of the use of the line was during the dry season, and we had no difficulty with it, and were feeling quite happy in the belief that we had a pretty well perfected plant, so far as line insulation was concerned. Then came along the fogs of the following winter—the winter of 1896-7. It was a winter in which, in the San Joaquin Valley, the land fogs were of longer duration than had been known in a good many years, and the almost invariable rule is that in our climate there, whenever a low pressure era and a storm comes on, the fog will continue right up to the time of the storm, and then we will have a severe, heavy storm, which, in the course of two or three days, will be followed again by another land fog, which will continue on until the next storm, but it may possibly taper off and gradually disappear with quite a space of time between the fogs. During the heavy storms of that winter we had quite a good deal of difficulty from the burning off of the pins. I went into the subject pretty carefully, and I found that the pin almost invariably burned off at the point where the lower petticoat came in contact with the pin, and that in nearly every case where we had an insulator which burned off it was one that was cracked or defective in some way in the outer petticoat. The water from the rains and fog went down through the body of the insulator and formed a path for the current to the pin, and whenever we replaced any of these insulators where the pin had burned off, we always took great care to select sound ones, and at the same time we coated the pins with P. & B. paint, after being thoroughly boiled in paraffine. Since then we have had no recurrence of the burning of pins.

The matter of insulators has been discussed quite a good deal, and I have been watching very carefully all the discussions and all the different types of insulators that have been brought out, and have, in addition, made experiments in the matter of insulation to our own satisfaction. The conclusion I have come to is that for an insulator, the one main point on which you must be absolutely safe is the matter of having a dry space between your line and your pin. You must have a roof that will preserve an absolutely dry air space under the insulator in order to have perfect insulation for a high tension current; and for that reason, in making our extension to Hanford, we chose a glass insulator. There has been a great deal of talk about the hydroscopic qualities of glass, and the effect it would have, but the first 10,000-volt transmission line that was built used glass insulators from the first. It is running to-day, and we have never heard of such a thing as a pin burning off, from those people—that is, the Pomona plant. The type of glass insulator that was furnished us by the agents for the Locke insulator was such that I was satisfied it would give satisfaction. We made a very careful visual examination of all the insulators that were put on the line, and we made some static tests on them. These glass insulators are not only cheaper than porcelain, but they are better in every way. There is a good deal of argument as to the matter of strength. We will, in railway or incandescent work carry heavy copper wires on glass insulators that are very light compared with the ones used in transmissions, and yet we think we must have a very heavy, strong insulator to carry a No. 4 or 5 wire in transmission lines. As far as mechanical strength is concerned, our insulators will prove amply strong for any strain that will ever be upon them.

We ran a voltage of 10,000 to Hanford as a matter of experiment, but as it was during the dry season, it was not a fair test. Our insulators are glass, with wooden top pin, and iron bolt and porcelain base, and I think that eventually some such type of insulator as this will be the one that will be finally adopted for all high tension transmission work. We expect, in the latter part of the fall, before the rains come on, when we get our high-tension line in operation, to change the insulators on our main line from the Fresno power-house to the same type of glass insulators that we have on the Hanford line. The porcelain insulators will give us no trouble whatever as long as the weather is dry. Just as soon as the wet weather comes on we will not feel safe in running our 19,000 volts on the porcelain insulators.

ENSIGN ON INSULATOR TESTING.

The Chair: Bearing on the other side, as I know Mr. Ensign has made a number of very interesting experiments running up to 65,000 or 70,000 volts on porcelain insulators under conditions approximating a very severe driving rainstorm, I would like to have him give the association an account of his work there.

Mr. Ensign: When we were trying to decide on an insulator for a 30,000-volt line, we heard all the opinions concerning the hygroscopic condition of glass, but we started out prejudiced for glass because glass cannot be punctured under such a voltage. I had satisfied myself that the trouble with the porcelain insulators used on the Folsom and Fresno lines was due to porosity, as could be demonstrated by breaking them open. The burning off of the pins was due to the current passing through the insulator to a point where the pin was wet close up under the lowest point of the threaded portion, at which point the potential, being sufficient to puncture the glaze where the insulator did not protect the pin from being wet, would form a small arc, gradually burning the pin off. But in looking for a glass insulator at that time, I could not find one large enough to stand the potential without the distance from the tie wire to the pin being too near the sparking distance of the potential used, so we were rather forced to the porcelain insulator, strongly guaranteed by the manufacturer. The insulator which we decided upon measures about six and one-half inches across the bottom by about four inches from the tie groove to the bottom of the outside petticoat, and instead of being round on top the top is squared down at the ends of the groove so as to give more of a right angle turn for the tie wire. They are sold to us under a guarantee not to puncture under a test of 70,000 volts. They will stand that voltage in dry weather with the top of the insulator immersed in water to the depth of the tie groove, with a terminal inserted in the pin-fit and the voltage applied to it, the pin-fit and grooves between petticoats being filled with a little water to help find cracks, if there are any. So far we have tested three carloads, which have been found very satisfactory.

TESTING HIGH TENSION INSULATORS.

I find that 66,000 volts, applied between the tie wire and pin, in ordinary dry weather, does not show the slightest tendency to jump around the insulator, although there will be a fine brush discharge in very foggy weather, sometimes jumping around with a sharp report, but not sustaining an arc. As this is four times the strain they will receive upon the line, we feel that it is a very satisfactory test.

The same insulator, mounted in the same manner as used on the line and tested for rain effect, showed a phenomena which has not been mentioned, to my knowledge, in connection with high potential insulators, which is that the height of the outside petticoat above the arm has a large bearing on the leakage and possibility of short circuiting during a rainstorm. In other words, the current seems to prefer to follow the path of the drops to the arm rather than jump across the shorter path to the pin. I took a potential of between 45,000 and 50,000 volts as being a safe voltage with which to determine the size of the insulator as regards rain for a 33,000-volt line. We turned the water on from a garden hose, using a very heavy spray, and gradually raising the insulators by putting porcelain washers on the iron pins, until we reached a height that would show no leakage, either by measuring the energizing current of the transformer or by a visible spark. We magnified the fluctuations of the energizing current by running the current through a water rheostat and connecting a 20 to 1 ratio transformer with the low potential side in multiple with the rheostat, putting a voltmeter on the 2,000-volt side, in that way magnifying the fluctuations of current enormously. These experiments were conducted in the dark, with hydrant water turned on in a thick spray. If the insulators were too close to the arm, there would be a fine, threadlike discharge to the arm from the outer edge of the insulator, and such a discharge would cause the voltmeter needle to swing violently. We found that at 45,000 volts, with the insulator four inches above the arm and a large number of insulators rigged up, we could absolutely detect no leakage. We then took these same insulators and raised them up six or seven inches above the arm, and raised the voltage to 66,000 volts. The leakage was still inappreciable.

Our method of testing was to place twenty-five inverted insulators in a wood tray with water up to the position of the tie wire, one terminal of the transformer being placed in the water. Mounted on a framework were twenty-five iron pins, which could be dropped at once into the twenty-five insulators. Each of these pins had a spark gap one-sixteenth of an inch long between it and the wiring of the frame. When the insulator did not offer any leakage for the current, there would be no perceptible spark in daylight, but in the dark there would be a fine blue thread; but as soon as the slightest leakage occurred, it would change to a yellow color, and when the insulator would break down to a red flaming arc. I found some curious things in these tests, one of which is that it is of no use to test insulators without having a transformer of considerable capacity. You may get leakage from dust, or a weak insulator, which, while it will not break the insulator down, will not allow the transformer voltage to come up to the required test because of the C. R. drop in the secondary. For instance, with twenty-five insulators in the tray, and gradually raising the potential to say about 15,000 volts, the weakest insulator would break down; if we put another one in its place, perhaps the next time we would get to 20,000 volts and down would go another insulator, until finally we got the whole set of twenty-five to stand the 66,000. But as we would approach the limit, we found we would have to wait a moment or two to give the voltage a chance to rise without applying any more current to the transformer. This was especially noticeable if there was a slight leak, due to dust or dirt on the outside of the insulator. We had on a static voltmeter, which showed us what we were doing all the time. The tests which they made on insulators at Niagara Falls were made with a very small transformer, and some of the small insulators sent us broke down at about 15,000 volts.

We are pretty well satisfied that we have an insulator which will do our work, though I would prefer glass if I could get one large enough, at the same time free from cracks. I met a young man from Telluride, who said the only trouble they had with a five-inch glass insulator was if they shut down from any cause during a rainstorm they could not start up again. They have the same insulator which is used at Yuba River plant and that Mr. Eastwood is also using. I have tested one of these insulators, and the current will jump from tie wire to pin at between forty-five and forty-eight thousand volts. That was too small an insulator for us to use on our 33,000-volt line. When we are reaching these very high potentials, I think our insulators should be large enough to stand double the line potential between pin and wire. The time we decided upon our insulators we could not get a glass one large enough which was perfectly solid.

I have some photographs here showing method of testing which may be interesting, and will pass them around. We punctured between 15 and 17 per cent. of the first that were sent out. They had no method of testing at the factory.

Mr. Lee: The glass insulator used on the San Gabriel line is a five and a half inch Locke insulator, weighing about four and three-quarter pounds, and designed for a working voltage of 20,000 volts, and I think the guarantee was that it would stand an insulation test of 40,000, which I think it will do. It is practically impossible to puncture glass that is sound, and it takes about 45,000 volts to go around it. If you take a hammer and hit a porcelain insulator on the head, where the tie wire is, sufficiently hard you will shatter it, and the same is true of glass; but if you only hit the petticoats, as a rule the outer petticoat is the one that will break. One great advantage in the glass insulator is that you can make a visual examination for cracks, which loom up very prominently. All you have to do is to clean the insulator over and you can see the cracks. The "checks" we have noticed in the ones shipped from the factory have not run over 1 per cent.

We understand these checks are due to the annealing of the glass. The question of the glass being hygroscopic is disposed of, because under the most severe conditions, that of a rainstorm, the hygroscopic features are lost sight of, and in dry weather both insulators will get covered with dirt. The Marysville glass insulators stood a test of about 36,000 volts on the line in dry weather.

Mr. Ensign: I believe the insulator is good for 22,000 volts, and at that voltage perfectly safe in any kind of a rainstorm, but I would certainly limit it to 22,000 volts. There they were running at 40,000, and from my experience it was too small to stand 33,000.

The Chair: I look forward to the time in the near future when we are going to eliminate the large element of copper cost from our calculations, and are going to run up to 50,000 volts as a common thing.

Mr. Ensign: Our experience has been on one of our lines, and not a great while ago we changed seven insulators in half a mile. It was a shotgun in that case. You could see the marks of the different shot, and the petticoats were all blazed off of one side and on another one all the way round, and there was nothing but the core left, and that was still carrying the wire, which had been thus carried through some severe rainstorms. I have known at least three insulators in the last year that have been that way. They were small insulators.

Mr. Eastwood: We would be very happy indeed if we had not any more trouble than that which is caused by people shooting off petticoats.

Mr. De Sabla: We have very little trouble with our low voltage, but from what Mr. Ensign is saying about people shooting at insulators, we have both the porcelain and the glass, and we prefer the glass ones, as they are less attractive. All shooting is done at porcelain insulators, and we have not had one single shot at the glass insulators. So I will side with Mr. Lee in favor of glass insulators, on the ground that they are less attractive to the eye.

Mr. Lighthipe: Mr. Eastwood's remark about not having any insulators shot makes me remember that the Fresno line is so far away from anywhere that nobody can find it. On the road to the power-house you see the line about once; the rest of it is several miles away from the road off on the top of a mountain. A great many lines run along the county road, and there is where the insulator gets it.

On motion, the Convention then adjourned.

ANENT TRANSFORMER COOLING.

(Communicated after adjournment.)

Mr. R. S. Masson: Reading over the "Random Notes" and the discussion which followed at the recent convention of the Transmission Associatian, has given me much pleasure. I should like, however, to offer a few remarks on some points of the same.

The quiet prosecution of high voltage experiments in 1896 at 60,000 volts was done with Westinghouse transformers and lightning protecting apparatus, by Westinghouse men, in conjunction with Messrs. Nunn brothers, of Telluride, who have now built the Provo plant. Much credit is due to the Nunn brothers for producing the facilities, and much also to the Westinghouse company for producing the necessary and successful apparatus.

The conclusion drawn that manufacturing companies are afraid to build and guarantee high tension transformers, since they will not assume "responsibility for loss of business or other damages resulting from breakdowns' is hasty. No company will assume such responsibility for a 110-volt generator, and yet they are not afraid to make and guarantee them.

One might easily conclude from the contention on the subject of high efficiency versus good insulation, that the transformer having lowest efficiency would be the best to use. There are advantages in high efficiencies, however, and insulation may be made sufficient for each specific case without indefinite increase in dimensions. After sufficient insulation is applied, there is no objection to improving the efficiency of the transformer.

I am interested in the information conveyed to me that line loss at 60,000 volts is twenty-five per cent. of what it is at 30,000 volts. The copper loss would be twenty-five per cent. if the power factor remained the same, but the leakage would be increased to twice as much or more. Capacity and self-induction would change, and the total loss at 60,000 volts would be far above twenty-five per cent. of the loss at 30,000 volts.

Regarding the fullerboard versus mica conclusions, there is a lack of data in the hypothesis. Mica has its place and does not conflict with fullerboard.

I cannot follow the arguments about the uneven temperature produced by a water-coil "running through to the bottom." We want an uneven temperature, or we do not cool the oil. If hot oil rises around the transformer we wish to cool it, and after it has fallen to the bottom of the case, it is ready to rise again and continue to take heat from the transformer. This means uneven temperature; therefore let us use the coil going "through to the bottom."

The idea of protecting the entrance of wires into a building by glass or marble panels is excellent. I shall use it hereafter. The insulator and pin statements agree with the conclusions reached by the Association at Santa Cruz in 1897.

Two classes of transformers are in use. They are related by the nature of their work, but require entirely different considerations and constructions. Much of the discussion showed that experience from one class was taken as evidence for the other. A street transformer of a twenty-light capacity at 2000 to 100 volts, filled with transil oil accumulating dust, and having its terminals, and possibly the case, covered with oil and dust, is in one class. A station transformer of 100 kilowatts capacity at 15,000 to 2000 volts, filled with clear, transparent mineral seal oil, is in the other class. This Association was presumably discussing the latter class. Most of the experience mentioned was undoubtedly in the former class, and does not apply to the latter.

"Bridging of impurities" in a flood of circulating oil where solid insulation stands between coil and coil, layer and layer, turn and turn; "trouble with the terminals coming out of the case," which no one has; oil in the coil forming a "bridge on the magnetic line," suggesting a novel idea—the magnetic property of oil; "impurities going into the very center of the coil through paper, linen, and shellac;" a transformer keeping cleaner with an air-blast throwing moisture and sand into it, than it would in an iron case covered with oil; an air-blast transformer requiring "no external device"—except a blower and motor air ducts and air pump for cleaning, and a few other items; the fact that you can get at all parts of an air-cooled transformer, especially the air ducts through the core and coils, without taking it apart; and that Mr. Eastwood found "large cakes of dust," and the question, "did he find them all?"—these points all show that the statement "I am not in position to debate" was correct.

The General Electric Company "are drifting away from oil." When did they use it? Not since they built some of their earliest high tension transformers—those on the Folsom-Sacramento transmission. It takes it a long time to drift. There must be a restraining force.

The gentleman did not observe that low efficiency of transformers means increased heating—a very bad feature.

I have never experienced the trouble mentioned about finding a fault; nor did oil fill up all of the punctures. When it did, I was satisfied, since I knew nothing about it. When it did not fill the punctures, there was plenty of evidence of the whereabouts of the trouble, such as lumps of melted copper.

Air cooling was said by one gentleman to be "precluded by the necessity of having a motor and fan." At Marysville the same gentleman installed a motor and pump to get water. True, the reservoir used acts for fire protection, but fire reservoir pumps run one or two days in a year; this one runs all the time. If it stops, the plant stops after the reservoir runs dry. Fires which tend to be disagreeable would naturally come at this time, leaving the station without protection. If you buy water, it is an expense. Air is cheap. For sub-station work, air-cooled, oil-insulated transformers have many advantages. At Santa Cruz, there is no attendant at all on duty at the sub-station. Power and light are used day and night, and during two years' operation, no one has ever gone into the transformer room except to take a look around. There was no water to stop, no pump to run, no fan to look after, and they did not use the fire hose to clean out a pipe. They are self-operating.

The Central California Electric Company has had some trouble; but this line is the longest 15,000-volt line which has operated for any considerable time. Length of line and amount of voltage make a considerable difference.

If insulating material is perishable, it should last longer under oil than in an air and sand blast of changing humidity. I do not agree with the "perishable goods" remark.

I am surprised to know that the General Electric air-cooled transformer, with its excellent conditions, should melt solder at its terminals, and that "the heating of twenty-four-hour service will cause a little solder to drop out," and that it is necessary to re-solder the connections at intervals.

The capacities for overloads, etc., are qualities of transformers, not types of transformers.

The President's conclusion that oil-insulated, water-cooled transformers were in favor, was reached without any arguments being presented on the type of oil-insulated, air-cooled transformers. I believe if he will read over all of the points made, leaving out the unsound and guessed-at points, and keep in mind all the while the oil-air transformer, he will see that this type has more of the good features and less of the bad ones than any other type. For sub-station work where the attendance is not continual and small units are used, the cost is the same as for water-cooling, and this type is excellent. At generating stations or large sub-stations where large units are used, a slight decrease in the cost per kilowatt is important and water-cooled, oil-insulated transformers are the best practice.

CONCERNING THE QUIMBY PUMP.

(Communicated after adjournment)

Mr. Charles C. Moore: Your secretary advises me that during the discussion which followed the reading of Mr. Richards' paper on centrifugal pumps, information was asked for concerning the Quimby pump, and in order to show how far the pump in question is adapted for use from electrical circuits, I may state that the Quimby pump for direct connection to electric motors has a very high efficiency against a wide range of pressure, because: (1) the power is applied direct; (2) the thrust due to the back pressure of the column of liquid in the delivery pipe is perfectly balanced, as the delivery opening is placed in the middle of the cylinder and the endwise pressure upon the screws in one direction is exactly counterbalanced by a like pressure in the opposite direction; (3) the absence of rubbing surfaces and consequent absence of internal friction, space enough being left between the screw and the cylinder and between the faces of the intermeshing threads to allow a close running fit, without actual contact; (4) the rotary motion of all moving parts and the continuous flow of the liquid delivered being free from pulsation.

That there is realized the high efficiency which the above would lead one to expect, is shown by the following test of a Quimby pump made by J. H. Clark, of the Power Mining Department of the General Electric Company at Schenectady, N. Y. The pump was direct connected to a 200-volt multipolar motor running at 1,100 revolutions per minute, and the results of the test are as follows:

Total Head and Suction Pounds.	H. P. Input.	Gallons per Minute.	Eff. Combination.	Eff. Pump.	Eff. Motor.
14.6	5.4	274	43.0	70.0	61.0
22.6	7.0	267	50.3	72.2	69.5
42.6	10.6	253	59.1	73.6	78.3
62.6	14.3	236	60.0	73.0	83.2
82.6	18.2	227	60.0	71.0	85.5
102.6	21.9	218	59.5	67.8	87.2
122.6	26.6	208	55.9	64.0	88.2
142.6	31.2	201	53.5	60.0	85.8

These pumps have been extensively used for various classes of work, being adapted to general pumping, irrigating, or either the pressure tank, gravity, or direct pumping electro-hydraulic operation of elevators, and owing to the absence of valves it handles thick liquids easily and efficiently.

(Communicated after adjournment.)

Mr. F. O. Blackwell: I have read with interest The Journal of Electricity giving a discussion upon high tension transformers which occurred at the Second Annual Convention of the Pacific Coast Electric Transmission Association, and, referring to air-blast transformers, it is a mistake to speak of them as having an air-insulation. While the small air ducts between the coils do, to a certain extent, increase the voltage required to jump between the primary and secondary coils on transformers of high potential, the resistance of this air gap and the surface insulation between coils is practically negligible. We believe that the insulation on our coils is sufficient to stand the high pressure without trusting at all to the spaces between them. Consequently there can be no serious reduction in the strength of the insulation of such a transformer due to an accumulation of dirt in the coils. I am not afraid of the accumulation of dust until it reaches a point which will seriously impede the circulation of air through the transformer.

Gas

PROPERTIES AND DANGERS OF ACETYLENE.*

THE lighting power is about fifteen times that of coal gas, the heating power more than twice. Every burner has a best pressure, generally from 1.2 to 1.6 inch water. A new Bray 0000 burner, using 0.95 cubic foot per hour, gives 43½ candles, with a pressure of 1.28 inch; but the burner is hopelessly blocked in twenty hours (Weber). Billwiller's burners (two converging jets at right angles to one another dragging air with them) work for months on end, giving 26 candles for 0.77 cubic foot per hour. The temperature of combustion should be very high, 2,500° C.; but it is lower (900° C.) than that of the Welsbach mantle (1400° C.). The flame of acetylene is a succession of minute explosions analagous to a discharge of rockets. At the German Mint an acetylene bunson flame rapidly got up temperatures above 1500° C., and melted in thirty minutes a quantity of nickel which had previously taken eighty-five minutes. The flame is bright and very actinic (photographic), the spectrum is very like that of sunlight, and colors are distinguishable in the light. Acetylene and air are explosive within a very wide range of proportions, from 5 to 62 per cent. (Le Chatelier), 3 to 72, or even 80 (Bunte), instead of 8 to 30 as in the case of coal gas. The fiercest explosion takes place with 1 acetylene to 9 air. Pure acetylene at the atmospheric pressure decomposes at 750° C.; a mixture of at least 35 per cent. of air with acetylene decomposes at 480° C. (Le Chatelier). At a works in Veszprem, Hungary, the yield at which is 5,250 cubic feet per hour, the temperature is kept below 30° C., so as to keep down impurities. The phosphoretted hydrogen goes up to 0.95 per cent., and the arseniuretted hydrogen up to 1.71 per cent. The light is 8.77 candles for 0.3 to 0.325 cubic foot per hour; and it has been noted there that acetylene dried over carbide, very rapidly dries up the joints of the pipes, so that these become leaky.

PROPERTIES.

COMPRESSED AND LIQUEFIED.

Compression of acetylene increases the rapidity of propagation of combustion, and lowers the kindling temperature. At two atmospheres it is explosive, even in a tube 160 inches long and 0.8 inches in diameter (Berthelot). Gerde's experiments in acetylene at six atmospheres show how heat applied to a pipe causes an explosion of the gasholder 60 inches away, the pipe being 0.2 inch in diameter. At 0° C. and 26 atmospheres pressure, 855 litres of gas become 2.2 litres of liquid, of specific gravity 0.45 (water being 1). The liquid is extremely expansible, so that we should never fill a cylinder with liquid acetylene to more than three-tenths its capacity. Acetylene is readily frozen to snow. At 15° C. the pressure exerted by liquid acetylene is 38 atmospheres; at 38° C. it is 68 atmospheres; but beyond this temperature (36.9° according to Ansdell and Gerde) it is not possible for the acetylene to remain liquid; and there is no recipient strong enough to stand the pressure induced by its reassuming the gaseous condition, for the gas produced would be at a pressure above 6000 atmospheres, and the too venturesome experimenter would run a risk of—forgetting what the observed pressure was. The pressure becomes so high because of the heat liberated on the break-up of the endothermic compound. One cubic foot of liquefied acetylene represents 360 cubic feet of acetylene gas; one cubic foot of carbide represents 660 cubic feet of gas; the respective weights are 28⅛ and 137½ pounds per cubic foot. But the question seems to be settled so far as regards liquefied acetylene, which is now prohibited by law in most countries of Europe. Acetylene dissolved in acetone under pressure is also complicated; and recourse must be had to the carbide itself for the lighting of vehicles, etc., so that we have to consider the best means of overcoming the difficulties incident to producing the acetylene as it is required.

DANGERS.

M. Bouvier then gives a list of twenty-nine accidents due to acetylene during 1896 and 1897, and resulting in nineteen deaths. The dangers incident to producing acetylene as it is required seem to be the following: 1—Local heating of carbide to a red heat, when not completely covered by water, in a vessel from which the gas is not allowed freely to escape; the compressed gas is highly explosive under such conditions. 2—Irregular rushes of gas when the lime falls off the carbide (bicycle lamp explosion at Lyons). 3—The easy kindling of the gas, by a soldering iron or a cigarette, 480° C. 4—The extreme rapidity of propagation of flame in an explosive mixture of air and acetylene, especially under pressure. 5—The wider limits of explosibility. 6—The slow diffusion between escaped acetylene and the surrounding air, the two gases having very near the same specific gravity, acetylene, 0.91, and air 1.00. 7—The rapid permeability of rubber by acetylene. 8—The shattering character of the explosion of mixtures of air and acetylene. 9—The circumstance that compressed acetylene of which a certain quantity near the mouthpiece has become mixed with air will go off as a whole if that small quantity of the mixture be fired, for the irritation is enough to cause decomposition and evolution of heat which travels through the whole bulk. 10—The spreading backwards of an explosion in the same way where local heating is induced by allowing the gas to rush at too high a pressure through too small an aperture. 11—The accidental impurities of acetylene, siliciuretted and phosphorretted hydrogen and ammonia.

---

*Abstract of a paper read before the Societe Technique du Gaz, 1898, by M. Ad. Bouvier.—"The Gas World," London.

SAFEGUARDS.

The risks then, are undeniable. Can they be avoided? There are only two methods of using acetylene other than pure acetylene. These are dissolved acetylene and diluted acetylene. As to the former, acetone dissolves, practically, 200 times its volume at 12 atmospheres pressure; about one-third the gas that may be obtained from an equal bulk of carbide. But it seems that the running back of a flame might do terrible havoc, for the acetylene going off will get up a high pressure, and at 20 atmospheres the acetone would go off too. In any case 12 atmospheres pressure means a heavy recipient. As to dilution, acetylene has been diluted with air, even by lecturers on the subject, in the United States. Then came nitrogen, but of this nothing much seems to have come. Then came carbonic acid, which is a promising idea (Kruger, Charlottenburg, 1895; Goodwin, Dublin). The Paris municipal laboratory experiments settled it that 10 or even 20 per cent. of carbonic acid affects the lighting value of acetylene by less than 10 per cent. of its amount. It seems as if the carbonic acid played the same part as the thoria in a mantle does in relation to the ceria, according to Dr. Bunte's explanation. Carbonic acid greatly reduces the risk of explosion, but it does not seem to be known what its effect is as regards the deposition of carbon in the burners. It enables acetylene to be used in motors, by diminishing the violence of the explosion. One inventor worked up dry carbide, a dry bicarbonate, and a dry acid, so that the product, which he called "acetylene," might give off a mixture of acetylene and carbonic acid; but nothing seems to be heard of this now.

M. Bouvier went on to discuss the use of acetylene mixed with coal gas and with oil gas, and the conclusions he reaches are that acetylene with oil gas is practical; acetylene with carbonic acid is probably so; acetylene alone is risky; and portable acetylene lamps may actually be considered to be dangerous.

Traction

ELECTRIC TRACTION DISCOUNTS STEAM HAULAGE.

A STRIKING instance of economy in actual money and elimination of trouble and delay induced by supplanting a steam haulage service with electric traction, is afforded by the installation recently made by the General Electric Company for the Arlington Mills, Lawrence, Mass. These mills have about two miles of track running from the main line of the Boston and Maine Railroad into the yards and throwing off spurs into the alleys between the different buildings. Previous to the change to electrical service, the haulage of the entire output of the mills to the main line, the haulage of the material from building to building, as well as the necessary switching about the yards, was done by a steam locomotive rented from the railroad. For this service the Arlington Mills paid an annual rental of several thousand dollars, and were, moreover, frequently put to great inconvenience and delay on account of the unavailability at times of any locomotive.

The successful results obtained with electric factory locomotives by other mills in New England, notably at Whitinsville, Mass., and Taftville, Conn., attracted the attention of the managers of the Arlington Mills to the question of electric haulage which they took into serious consideration. As every case in which electric traction has been adopted in factories showed an improved service, as well as an actual money economy, electricity as a motive power was decided upon.

The electrical installation consists of a small generating plant and two electric locomotives, one of the box type and the other a platform car. The generating plant consists of a standard GE. seventy-five kilowatt, 500-volt railway generator driven by belt from a high speed engine. The generator readily answers all calls upon it, with absolutely no heating or sparking, although it is occasionally subjected to very heavy overloads when both cars are handling a train of more than the usual number of loaded cars.

The box car locomotive used for hauling material about the yards is equipped with two GE. 800-27 horse-power motors and series parallel-controllers. The platform locomotive is used to haul trains of loaded cars, and its equipment consists of two 50 horse-power GE. 1200 motors with the necessary series parallel controllers. In hauling heavy trains it is assisted by the box car locomotive, and together, they are able to handle trains of thirty to forty empties, or twelve to fourteen loaded cars, with comparative ease and celerity. To give the necessary adhesion to the more powerful locomotive to enable it to handle heavy loads, about six tons extra is placed on the platform.

A BOX CAR LOCOMOTIVE AT THE ARLINGTON MILLS.

Perhaps the most interesting feature is the comparison between the cost of the electric plant and the expense formerly entailed by the use of the superceded steam locomotive. No more men are employed about the electric locomotive, the labor cost has not risen, and the consumption of coal is scarcely felt on the main plant. Furthermore, the plant being always ready, cars may be shifted at any time during the day or night.

The new system is thus both economical and advantageous and the appreciation of the Arlington Mills is, perhaps, best shown by the fact that a second platform locomotive is shorly to be added to the haulage plant.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

TWO MAMMOTH CONTRACTS.

MORE than passing interest is always attached to record-breaking achievements, and the Walker Company, of Cleveland, Ohio, is to be tallied with two counts on this score for remarkable contracts it has secured during the past six weeks, the first of which is said to be for the largest order for alternating current machinery ever placed at one time, and the second is for the largest railway generator ever built.

The first contract is from the Union Carbide Company, of

Chicago, for the building and delivery of twenty 500 horse-power alternating current generators, single phase, sixty cycles, to deliver a current of 2500 amperes at 200 volts. Besides these, there will be five 100 horse-power direct current generators as exciters, and a complete switchboard for all of these machines. The spot selected for this mammoth plant. which is to be run entirely by water power, is at the falls of the Soo at Sault Ste. Marie. The Union Carbide Company has acquired rights of manufacture of calcium carbide for the United States and will have its main works at Sault Ste. Marie. The carbide is at present manufactured at Niagara Falls, the electric power necessary being supplied by the Niagara Falls Power Company. The output of the Niagara plant is about ten tons per day, while that of the works at the Soo will be 100 tons per pay. The works are to be built for the accommodation of forty generators and forty electric furnaces, where the lime and carbon are fused into calcium carbide, the twenty generators in this first contract being but the initial order.

The second contract is with the Boston Elevated Railway Company, under which the Walker Company is to furnish a generator capable of delivering in regular service 6000 amperes at a voltage of 550, and capable of delivering upon overload about 9000 amperes. The generator will be rated at 3000 kilowatts, and will be direct-connected to a 5000 horse-power engine. It will have twenty-four poles, will stand twenty feet high, and will weigh 300,000 pounds. Its armature will be fifteen feet in diameter, and will alone weigh 125,000 pounds. The commutator will have 1200 bars, each two feet long and four inches deep, and the armature shaft will be three feet in diameter. The unit will run at 75 revolutions per minute. The machine will have an adjustable compound winding, by which its rate of over-compounding may be changed at will to provide for variable loads at different times of the day. Altogether this machine will represent a development in railway practice to higher things than have yet been attained, and the best results are expected. The contract was placed with the Walker Company after a careful inspection by the engineers of the Boston Elevated Railway Company of the large Walker generators in the Kent avenue station, in Brooklyn, which have been giving very good service. These generators were put through some of the severest tests possible to devise, such as breaking circuit instantly on full load, and no trouble whatever was found, the brushes even remaining practically sparkless at the break.

The Wybro-Hendy Company, 38-44 Fremont street, holds the Pacific Coast agency for the Walker Company.

A MERITORIOUS INCANDESCENT LAMP.

WHILE much attention has been recently given to the development of the enclosed arc lamp, equal, if not not greater study has been devoted to the further perfection of the incandescent lamp, not only with the view of making it more serviceable and efficient, but in order that it may effectually compete with the arc lamp in the illumination of interiors. As a result, some incandescent lamps have reached a high degree of perfection, and among these is the "Pacific" incandescent lamp sold through the agency of the Pacific Coast Electric Company of 1145 Market street, San Francisco.

The "Pacific" lamp is one concerning which much might be said, but so extravagant are the claims put forward by many incandescent lamp manufacturers that the makers of the "Pacific" lamp are perfectly satisfied to allow it to stand on its own feet, as it were, knowing full well that its merits will bear it successfully through any competitive test with any other incandescent lamp on the market. Efficiency, life and first cost are the factors determining the serviceability of an incandescent lamp. The life and efficiency of the "Pacific" lamp will soon be declared by any one who gives it a trial to be all that is claimed for it, while the selling price, as is shown in the advertisements is as low as any lamp on the market, and much lower when the question of serviceability is taken into consideration. It is a lamp that no station manager, or isolated plant, or incandescent light consumer can afford to pass by without a trial.

The Pacific Coast Electric Company is, by the way, a consolidation of the Pacific Coast Electric Company, formerly of 241 Powell street, San Francisco, and the California Electric Supply and Construction Company, which, under the management of E. H. Forst, has placed some of the largest and finest house service and incandescent installations in California. Mr. Forst has been chosen manager of the new concern, which is destined to be an important factor in electrical affairs of the coast.

WORTHINGTON PUMPS ON THE COAST.

The Pacific Coast agency of Henry R. Worthington, the well known manufacturer of pumps of every description, has been transferred from the Crane Company, and the business is now being handled as a branch office under the management of W. P. Eichbaum, with headquarters on the third floor of the Mills Building, San Francisco.

The Woodill & Hulse Machine and Electrical Works, of 108 West Third street, Los Angeles, has secured the contract for all the electrical work to be placed in the new Stimson building now in course of construction in that city.

TABLE OF CONTENTS.

Illustrated articles are designated by an asterisk (*); Editorials by a dagger (†); Passing Comment by a double dagger (‡), and Industrial by a section mark (§).

Financial

† The Influencing of Stock Values.................................... 39

Gas

Properties and angers of Acetylene............ 46
Rubber will not hold Acetylene.. 41

Illumination

Accumulator Variations and Acid Strength..... 37
§ A Meritorious Incandescent Lamp...................................... 48
* Electric Storage in an Edison Station, by Geo P. Low... 25
* Proceedings of the Electric Transmission Association—Concluded. 42
† Sister Industries, yet Estranged.......... 38

Literature

‡ "Science Abstracts"... 40

Mining

Electricity in Mining—IV.
  Operative Power in Mines—Concluded.......... 40
  Historical........................ 40

Miscellany

* Electric Traction Discounts Steam Haulage.......... 47
Electrolysis in Copper Refining... 41

Personal

.... 36

Telegraphy

Wireless Telegraphy in Commercial Service....................... .. 35

Telephony

Arc Lamps as Telephones 37
‡ Picture Transmission by Wire........................... .. 39

Transportation

§ A Mammoth Contract.... 47

Transmission

† Insulators, as Viewed by a Contemporary.......... 38
* Polyphase Induction Motors... 34
Starting Non-Synchronous, Single-Phase Motors..................... 37

THE JOURNAL OF ELECTRICITY.

VOLUME VI. SAN FRANCISCO, SEPTEMBER, 1898. NUMBER 3.

Building the Tramway Over Chilkoot Pass.

BY W. A. BURKHOLDER.

BUILDING an aerial tramway over Chilkoot Pass, or rather, to speak more accurately, the building of an aerial tramway *up* the Chilkoot Pass from the foot of the canyon to Scales, at the summit of the mountain, is an engineering problem of expedients and frontier experiences, rather than of technical detail. To begin with, the work was of the variety best known as a "rush job," but to make matters more interesting, the contract was executed in the depth of an Alaskan winter, with labor mildly characterized as "unskilled," and in a country where the monotony of having different parts, if not the entirety, of one's anatomy frozen, was varied only by the excitement of death dealing avalanches. Labor—spare the mark!—cost $3.50 to $5 a day and board. At times it was necessary to dig through twenty feet of snow before reaching the ground, and then, particularly during the last two miles of the line, the ground proved so hard that it was almost impossible to break it with dynamite, to say nothing of the difficulty, if not the impossibility, of thawing the explosive. It was at all times necessary to put the poles into the holes as soon as the latter were dug, or otherwise the holes would quickly fill with drifting snow. As to the weather, that at the foot of the summit is of a severity I cannot describe. It is with the greatest difficulty, at times, that one can stand up against the hurricane that blows there, and this, with a temperature perhaps far below zero, makes it almost impossible at times for human beings to exist there for any length of time. Both my cheeks were frozen one morning while making an inspection of the line, and a few days before, the hard frozen bodies of two Indians were taken from the trail. It was below this point that occurred the great avalanche of February last, wherein nearly sixty adventurous gold-seekers were buried alive, and which was so fully reported in the daily press at the time. Although the great avalanche crossed the pole line of the D.-K. T. Co.'s tramway, it did not injure it beyond tearing down a few stretches of wire. Nevertheless, the work on the tramway, which was begun on June 15th last, was completed on March 20th, when it commenced operations. The original plans for the building of the tramway of the Dyea-Klondike Transportation Company contemplated the erection of a power house, to be driven by steam, at Dyea, and an eighteen-mile transmission thence to Scales, at the foot of the Pass. This transmission was to be at 5000 volts, three-phase, with step-up and step-down transformers, and the equipment for it reached Dyea in January. On arriving on the ground, however, I advised against the transmission as proposed from Dyea, when the power house could be both installed and operated as cheaply and as satisfactorily at the mouth of the canyon as at Dyea. Some eleven miles of transmission line, as well as the raising and lowering transformers and all attendant losses would be obviated should the change be effected, and, accordingly, the power house was located at the mouth of the canyon.

LENGTH, 4000 FEET.
GRADE, 30 PER CENT.

A STRING OF HUMANITY
CLIMBING CHILKOOT PASS.

The generating station is a plain log building measuring

20×60 feet, and the steam equipment placed therein consists of a 16-foot by 64-inch marine type boiler, and an 11×12 inch automatic engine, from which is belt-driven a Westinghouse 45 kilowatt, two-phase generator, delivering 2000 volts. The station contained no "frills," but the behavior of the boiler is worthy of special mention. It was of the marine type, designed for burning coal under forced draught, but no coal was to be had. The only wood available was green hemlock, at $5.50 per cord, and while we did succeed in getting up steam, I have often thought that it was due to the sulphurous heat of the fireman's outbursts of wrath, more than to any calorific virtue of the wood itself.

Canyon City is nine miles above Dyea, which is the seaport for those who go to Dawson and the Klondike by the most direct route. The distance from Canyon City to the foot of the Pass is a little over seven miles, and along this distance the pole line passes, thence up the canyon to Scales. The poles are of thirty-foot spruce, cut from the mountain side, and measure from six to eight inches in diameter at the top, to from ten to twelve inches at the butt. In the canyon the line is run in the most direct route possible, the poles being set in holes blasted out of the solid rock, and so that the line runs from point to point along the side of the canyon. This pole line carries only the two-phase transmission circuit, consisting of four No. 6 B. & S. guage hard drawn copper wires, supported on Locke triple petticoat glass insulators, on wood topped steel pins. The transmission line is barreled twice in its length, and the poles also carry a telephone circuit.

PACKING OUTFITS.—BEFORE THE COMPLETION OF THE TRAMWAY.

The motor house at Scales contains a step-down transformer which reduces the line potential to 200 volts for driving a Westinghouse fifteen horse-power induction motor (type "C"). The motor is belted to a shaft operating winding drums through clutches, so that one of the drums takes up the cable while the other pays it out at the same speed. The outfit is a regular mine hoist, and was, in fact, taken from the Sheep Creek Mine near Juneau. The length of the cable, which is, of course double, is about 4000 feet, and the greatest single span is approximately 3000 feet in length. Loads varying from 1200 pounds to 1500 pounds are carried with ease up grades running as high as thirty per cent., and some parts of the tramway run along the side of the canyon from 500 to 600 feet almost vertically above the trail. It should be explained that the "D.-K. T. Co." tramway, which is now being described, consists of a traction cable of five-eighths inch plow steel, supported at intervals as close as possible, on staunch overhanging pole structures. On these traction cables run, or rather underrun, two buckets, not unlike two coal conveyors joined together, and these buckets are hauled along the traction cable by means of a pulling cable, also of plow steel, but having a diameter of one half an inch. It is this latter cable that is wound on one or the other of the two drums referred to, according to whether the buckets are being raised or lowered. The tramway, which is 4000 feet in length, is used only for freight, although employees have been over it often, and one young lady, a Miss Edgerton, who is a Red Cross nurse, made the perilous trip in safety shortly after the completion of the tramway. She was the first and only woman who ever went over the trip, despite the full page story in a New York Sunday paper describing, with thrilling attributes, the journey as made by one of its women reporters. The tramway is capable of handling fifty tons of merchandise daily, and the cost for the service is ten cents per pound from Dyea to Lake Linderman, which is a cut from the rate of forty cents which existed for the same service last fall. The rate for the 4000 feet of the Pass alone is one cent per pound.

So great was the activity of the transportation companies during last winter, that by the commencement of the season this summer, three different tramways were in operation over the Chilkoot. In addition to the one described, the Alaska Railway and Transportation Company were operating a single one-inch cable between the top of the hill above Stone House to the top of the mountain overlooking Crater Lake. This cable has a length of about 7000 feet and is run by a forty horse-power gasoline engine. The third system is known as the "Bleichert system," and uses a steam plant for operating its tramway from Canyon City to Sheep Camp, and another for that section from Sheep Camp to the Summit. These three systems were consolidated early last summer, and now only the Bleichert system is in active operation. As might be supposed, life in Alaska during the memorable winter of 1897-98, bristled with startling experiences, one of which is brought out in the photograph of one of the towers supporting the traction cable on the Chilkoot tramway. This tower is at Sheep Camp, and the animated scene just beneath the tower shows a method of administering justice *a la frontier*. Two men were convicted by a committee as being guilty of stealing provisions from different outfits along the trail. A committee of five was appointed to determine on the punishment to be inflicted, and of the committee, two stood for lynching and three for public lashing. One of the thieves, fearing lynching, committed suicide by shooting himself through the head; the other was stripped to the waist and tied to the pole as shown, after which he was given seventeen lashes with a "cats' tails" of half-inch ropes, when a doctor interfered and stopped any further punishment. The crowd then placarded the trembling wretch: "Thief; pass him along," and marched him under guard to Dyea, fourteen miles distant.

SEVENTEEN LASHES FOR THIEVERY.

CACHEING SUPPLIES AT SUMMIT.

Charcoal much purer than coke, and therefore better suited for making calcium carbide than the former variety of carbon, is, it is claimed by a contemporay, being produced from sawdust by the use of retorts.

Steam

COAL COMBUSTION AND SMOKE PREVENTION.*

BY JOHN L. HOWARD.

THE problem of the prevention and abatement of smoke in the combustion of coal has long occupied the attention of chemists, mechanics, and inventors. For public and economic reasons the solution of this problem has been attempted in a variety of ways, and with varying measures of success. During recent years, however, the subject has assumed new importance as a public question in many Eastern cities, where smokeless fuels hitherto used in manufactories have been displaced by those that produce smoke, and the demand for a remedy has arisen from the owners of buildings that are threatened with soot discoloration, and from the public officials having regard for the appearance and health of their cities.

It may serve a good purpose if we take a brief and hasty survey of the character and composition of fuels, of the wonderful chemical operations that take place in the process of combustion, of the elements that are involved in it, and of the conditions that favor its completeness.

In commercial fuels we have examples of the three states of matter:

Solid—As in coal and wood, where the force of attraction binds together the molecules.

Gaseous—As in artificial or natural gas, where the repellant force separates the molecules.

Liquid—As in petroleum, where the two forces act in equilibrium.

These different forms of carbon, or of combinations with it, constitute the supply from which is obtained the material to produce light and heat.

In the consideration of coals, it will be found that there are two commercial divisions:

1. The anthracites, which are distinguished chemically by the presence of much fixed carbon and but little volatile matter.

---

* A paper read before the Sixth Annual Meeting of the Pacific Coast Gas Association, San Francisco, July 20, 1898.

They vary in quality within narrow limits, and are practically smokeless.

2. The bituminous, which grade into the anthracite condition, and are made to comprehend all below that down to the lower order of lignites.

Therefore, these have a larger range of quality. They have in less degree what anthracites have in abundance, viz.: fixed or non-volatile carbon, and they have a high percentage of volatile matter which is very low in anthracites. It is this difference which makes the general distinction between the anthracite and bituminous grades.

Let us look for a moment into the method employed to determine the constituents of coal and their quantative relations. A pulverized sample is accurately weighed and subjected to a heat of 212° F., until the weight becomes constant. The loss or the difference between this and the original weight indicates the amount of *moisture* that has been expelled. The crucible is then covered and the heat is greatly increased until the weight again becomes constant. The loss, or the difference between this and the preceding weight, indicates the amount of *volatile matter* that has been driven off; the balance is coke. When this has been burned a reweighing will indicate the amount of *fixed carbon* that has been consumed, as well as the remaining incombustible matter or *ash*.

This method of proximate analysis is the determination of contents by weight differences, giving the moisture, ash, fixed carbon and a chemically complex body called volatile matter, consisting chiefly of hydrogen and carbon in combination, oxygen and sulphur. It is this wonderful complex body that has special interest in this discussion.

We are now able to understand the cause for the great variations of quality in coals, due to the differences in the proportions of constituent parts, as may be more clearly shown by the following table of analyses of a few typical coals:

	Bituminous.		Anthracite.	
	Lignite, Seattle.	Australian.	Pennsylvania.	Welsh.
Moisture....	7.	2.52	2.50	.96
Volatile matter ...	31.75	30.57	2.224	5.82
Fixed carbon.....	58.25	61.05	90.276	90.63
Ash..............	3.	5.86	5.	2.59
	100.	100.	100.	100.

For the interest that it may have, I quote from "Wagner's Approximated Tables," showing the chemical alteration that has taken place in the progress from the lower to the higher forms of fuel:

	Carbon.	Hydrogen.	Oxygen.
Wood..........................	52.65	5.25	42.10
Peat..........................	60.44	5.96	33.60
Lignite.........................	66.96	5.27	27.76
Bituminous.....................	76.18	5.64	18.07
Semi-anthracite..............	90.50	5.05	4.40
Anthracite.....................	92.85	3.96	3.19

While this table shows the total of the fixed and free carbon, yet it indicates that in this progress there has been a constant decrease in the volatile matters until the highest condition is reached in the anthracite stage. We may now leave this preliminary survey of fuel composition, bearing well in mind that the elements concerned in combustion are: First, in anthracites, the fixed or non-volatile carbon, which ranges from 85 to 90 per cent. of the mass; second, in bituminous, the fixed carbon and also the hydrocarbons contained in the volatile matter, remembering also that moisture, oxygen, and ash are not concerned in it, and that the intrinsic value of the fuel is affected in the proportion that they exist.

We now come to consider the question of combustion, which is due to the chemical combination of atmospheric oxygen with the combustible elements contained in the fuel.

Chemistry has determined that 29.86 cubic feet of oxygen per pound of carbon, or two volumes of oxygen to one of carbon, are needed to produce carbonic acid gas, resulting from the *complete* combustion of carbon; that 89.6 cubic feet of oxygen per pound of hydrogen, or one volume of oxygen to two of hydrogen are needed to produce water, resulting from the *complete* combustion of hydrogen; and that 11.2 cubic feet of oxygen per pound of sulphur, or two volumes of oxygen to one of sulphur, are needed to produce sulphuric acid, resulting from the *complete* combustion of sulphur.

This relation of oxygen to combustibles is fixed and definite. If less be furnished the combustion will be partial; if an excess be furnished the combustibles will appropriate what they need and the detrimental surplus will pass away. Atmospheric air contains about 21 per cent. of oxygen.

Knowing this, and knowing also the chemical composition of any fuel, it will be seen that the amount of air needed for its combustion is calculable.

For example, a coal containing 90 per cent. carbon, 5 per cent. hydrogen, 3.5 per cent. oxygen, 1 per cent. nitrogen, and .5 per cent. sulphur, would require 143.98 cubic feet of air per pound, or 322.515 cubic feet of air per ton, of coal.

It follows, therefore, that, unless sufficient air carrying oxygen shall be brought into contact with the carbon and hydrogen to produce carbonic acid gas and water, the combustion will be incomplete and there will be a loss of heat energy.

Let us follow in part the chemical and physical changes that occur in the consumption of bituminous coal. When a charge of fresh coal is thrown on the fire the first effect is to lower the temperature of the furnace, because of the cold air that is drawn in through the open fire door, and because new coal at the atmospheric temperature (say 60° F.) is fed upon a bed of coals, the temperature of which may vary from dull, red heat, (say 1300° F.) to bright, white heat (say 2500° F.) The sudden reduction of furnace temperature is not conducive to chemical union at this critical point.

The distillation of volatile matter begins almost at once, and it has been found that, at a temperature of about 1100° F., most of the coal gases will ignite if the oxygen be present.

When the distillation process is completed, then the operation in the fire is the combustion of the fixed carbon, which is combined with the incombustible matter in the coke. The oxygen rushes to the carbon as it is exposed on the surface of the incandescent lumps and continues the attack until they are reduced to ashes. The product now is either carbon monoxide or carbon dioxide, according to the completeness of the process. It will be noticed that heat is essential and that the combustion will be intensified as the supply of oxygen is increased.

This burning of bituminous coke after the volatile products are driven off, is the same operation that consumes anthracite coal and artificial coke. It is the combustion of the fixed carbon, and the products are not visible.

Smoke may be called the *visible* part of the products of combustion. We have seen that it does not occur in the burning of anthracite nor in the consumption of the coke portion of a bituminous fire. We are, therefore, able to say that it is generated during the distillation of the volatile matter contained in bituminous coal, and it is due to the imperfect combustion of those gases. The ingredients chiefly concerned are the hydrogen and carbon. It has been found that the hydrogen constitutes only five or six per cent. of the coal constituents, and that oxygen has for it a stronger affinity than it has for carbon. We, therefore, conclude that some of the volatile carbon when in the gaseous state is not consumed, but is condensed or precipitated into the solid condition of soot, and we may further assume that this change from the gaseous to the solid condition will result from any of three causes: First, an insufficient supply of oxygen to consume the volatilized carbon of the coal; second, a want of thorough contact between that and the oxygen; third, unfavoring temperature conditions for the quick and complete combination of the oxygen and the volatile carbon.

It is upon these lines that inventors have worked to produce devices looking to the prevention of smoke.

It must be remembered that the *commercial* loss in the prevention of smoke itself, great as it may at times appear to the eye, is really unimportant, for the experiment has shown that bituminous coal, burned under very unfavorable conditions, yielded in soot only about one-half of one per cent. of the weight of the coal tested, and an analysis of the soot shows the actual loss to be immaterial. Far greater losses may be suffered in products that are not visible, for if the carbon be turned into carbon monoxide a heating power measured by 4500 British thermal units per pound of carbon is obtained; whereas, if the process be not arrested, and this gas, by the addition of one atom of oxygen, can be converted into carbonic acid gas, the resultant heat will be 14,500 British thermal units, or more than threefold.

The difference between the steam and gas men is, therefore, readily seen. In water gas making the struggle is for carbon monoxide, that erstwhile nightmare of our local journals, while in steam making the effort is to push the process on to carbon dioxide, a product which, to the gas man, is worse than useless. Again, in coal gas making, the method of destructive distillation employed is different only in so far as that air is excluded. The gas man finally burns his hydrocarbon through a jet under proper heat, and where the supply of supporting oxygen is abundant for perfect combustion of the gas, but the steam man finds it difficult to maintain the needed constant furnace temperature and to regulate the supply of air to meet the varying calls for oxygen during the process of volatilization.

The cry for relief has brought forth anti-smoke ordinances in such cities as Chicago, Cincinnati, Cleveland, Pittsburg, St. Louis, Detroit, Milwaukee, and Minneapolis, and like measures are under consideration in other cities. There seems to be only a half-hearted enforcement of such laws; in fact, the Chicago ordinance remained passive until an associatian of citizens took steps to compel an observance. History shows that London, which has suffered more than any other city of the world, sought legal relief 600 years ago, when the use of bituminous coal was made a capital offence. There have been spasms of legislation since that time, and still she suffers. The situation is greatly aggravated there, because of the hundreds of thousands of household chimneys that are contributing to pollute the atmosphere, and the domestic hearths are not as amenable to treatment as are the boiler furnaces of manufactories.

While the use of anthracite coal is spreading in England it will take much time to divert the trade from the long used bituminous coals, as indeed it would be diffcult to turn the household demand of the Atlantic seaboard from the anthracite.

The anti-smoke legislation in this country has had the effect, however, of greatly increasing the number and kind of devices intended to remedy or palliate the evil.

We have the principle of compelling the volatile gases to come in contact with the high temperature of incandescent coal, as is rudely attempted in the hand firing of the two sides of a furnace alternately, or by overfiring and drawing the gases down through a bed of live coals on an underlying grate, as was shown by James Watt, and more recently developed in the Hawley furnace; or by the use of dead plates in the front of the furnace, whereby the gases from the fresh coal would pass over the incandescent matter in the rear; or by pistons which push a body of coal from a front hopper into the furnace; or by underfeeding arrangements, where the fresh coals are automatically fed from an underlying trough and gradually pushed into the furnace, meantime the evolved gases being made to pass through the overlying bed of incandescent coals.

There have been numberless methods of introducing air with and without steam: through vertical perforated plates situated under the bridge wall, through split bridge walls, from the furnace sides in jets from above the furnace doors, through furnace doors, hot air, cold air and saturated air, above and below the fire, are all represented in the patents. The schemes seem to have culminated in what are called automatic stokers, of somewhat complicated and expensive mechanism, intended at one stroke to cover the entire range of involved problems. First, by a mechanical transport of the coal from the bins to furnace hoppers, and an arrangement of feeding on slow moving grates of different types, to reduce the number and cost of attendants connected with coal firing and ash removal; second, to keep an even and high furnace temperature by avoiding the opening of fire doors and the chilling effect of a body of fresh coal when scattered over the fire; third, to admit air in such way and in such quantity as to bring about complete combustion of all the combustible elements in the fuel.

The published experience of those who have used these elaborate systems is not *all* favorable to them.

I may close my paper with the relation of some personal experiences.

The effort to introduce Welsh anthracite smokeless coal as a steam fuel compelled us in some instances to guarantee economy, based upon its evaporative power and its cost as compared with grades of bituminous coal. This brought such knowledge from the tabulation of comparative steam making values that we finally did not hesitate to guarantee that Welsh anthracite, when burned under our system, would evaporate twenty-five per cent. more water than the best grade of Australian steam coal. We never failed in such an undertaking, because, with our method, the anthracite, with adjusted grate area and air space, and with forced draught, was burned under more favorable conditions than was the case with bituminous coal burned under the conventional methods.

This becomes the more apparent when you observe that the total of the heat giving constituents of a good bituminous coal and of an ordinary anthracite are nearly the same, and self-interest prompted a line of experiments to prove whether a bettering of the conditions would not make the combustion of the bituminous coals more complete, and thereby not only prevent the formation of smoke, but also secure the greater advantage of increasing its value by raising it nearer to the standard of evaporative power possessed by the anthracite coal.

After a somewhat careful study of the bituminous coals that come to our market, of their action in the furnace, and of the principles that underlie the classes of patents that have been offered, some experiments led us to observe that beyond the quantity of air and the temperature of the furnace, lay an important factor; namely, the method and the place of administering the air to bring about a thorough contact and union of the oxygen and the combustible elements of the fuel.

It may be stated that, in order to prevent any reduction in furnace temperature through the opening of fire doors, an automatic or other mechanical contrivance is necessary for the feeding of the coal and for the removal of the ashes.

There are comparatively few of the total number of owners of steam plants who recognize the ultimate value of these arrangements looking to economy, or who have the inclination to risk the investment of money in modern appliances. It, therefore, becomes necessary in this field of study, to devise a simple, effective, and not expensive apparatus that may be attached to boiler plants as they exist, without material changes in them.

It may be a matter of surprise to some when I state that, in the experiments to establish the ratios of air to be delivered through the grates and above the fire, the improvement in the evaporative power of the coal continued until we had delivered two and one-half times as much air above the fire as was permitted to pass through the bars from below.

This verified the theory that the proper administration of air had an important bearing upon the combustion of the fuel; for, as compared with the evaporative results obtained from burning the same coal with natural draught on the ordinary bars and under the best conditions, the effectiveness was raised from fifteen to twenty per cent.; and more than this, there was an absence of smoke and only a slight color when a highly bituminous coal was mixed with coal tar.

It will need further and severe testing under all conceivable conditions and with different grades of coal for final proof that the device merits the expectation of its projectors, but it is a long move towards the end for which experimenters have been reaching out and are now working with renewed activity and with greater hope of success.

The most perfect form of fuel is that in the gaseous condition; next in order is the liquid petroleum, when atomized and mixed with its proper proportion of air in the presence of a high temperature.

The highest evaporative power will be obtained from solid fuel when it is pulverized and introduced in the furnace properly admixed with air so that the combustion will be immediate and complete. Then the greatest heat energy will be obtainable, then the smoke will naturally cease; and almost within the grasp of invention is a small, effective apparatus, attachable to the front of a boiler, into which the coal of any size may be mechanically fed, pulverized and delivered into the furnace continuously. This, too, at a cost within easy reach of the owner of steam boilers. When this is achieved there will be no need of prohibitory legislation, because the self-interest of coal users will cause the adoption of economical appliances that in their operations will obviate the smoke nuisance.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of
Electricity, Gas, and Power.

Official Organ of the Pacific Coast Electric Transmission Association.

Subscription invariably payable in advance. Terms—Domestic, One Dollar per Year; Foreign, Two Dollars per Year. The trade supplied by the San Francisco News Company. Advertising rates furnished on application.

GEO. P. LOW, : : : Editor and Proprietor

PUBLICATION OFFICE:
320 CALIFORNIA STREET,
ROOM 14.

Address all communications to
Editorial rooms, 427 TENTH AVE.
Telephone, "Steiner 623."

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME VI SEPTEMBER, 1898 NUMBER 3

EDITORIAL.

A LOOK INTO THE FUTURE.

The presidential address of Sir William Crookes before the British Association for the Advancement of Science, gives the views of an eminent scientist on the possible part that electricity and kindred interests may play in the civilization of the twentieth century, and from a supposedly disinteresting dissertation on the food supply of the world, he unexpectedly startles electricians with an expression of belief in the probability that the famine in wheat and breadstuffs which threatens coming generations will be averted through the electrical reduction of the free nitrogen of the air into a fixed nitrogen fertilizer that will vastly increase the productiveness of the wheat fields of the world, which, by the way, are rapidly becoming impoverished despite every effort toward its prevention.

According to Crookes, every square yard of the earth's surface sustains about seven tons of free nitrogen in the atmosphere. Were this free nitrogen converted to a fixed nitrogen compound, such as nitrate of soda, and such as is required for fertilizing purposes, its present market value would be nearly $25,000. Only by means of the use of such a fertilizer can the supply of wheat for the world's constantly increasing consumption be maintained. Nature's production of nitrate of soda is limited in quantity and will soon be exhausted. Nature's store of free nitrogen is inexhaustible; it is as bountiful as the air itself, and Niagara alone is capable of producing the electrical energy required to reduce the free nitrogen of the air to the twelve million tons of nitrate of soda annually required to render the world's wheat fields sufficiently productive to fill the granaries during the coming century. The prospect of the installation and operation of the colossal electric plant necessary to fulfill this duty should be an incentive for earnest efforts to discover the means for commercially perfecting the crude laboratory experiment by which a fixed nitrogen compound results from the combustion of atmospheric nitrogen in a static spark. Here is a golden opportunity for investigation, and it is one, moreover, that is fraught with prospective rewards of the highest plane of humanitarianism.

A further surprise in the presidential address rests in the consideration of the resources of molecular movements, which brings out opinions that will be accepted by the general public as chimerical, yet how indicative of the unscientific nature of the public is this doubt! In what other light than that of astonishment, not unmixed with incredulity, will the layman view the statement that, "The total energy of both the translational and internal motions of the molecules locked up in quiescent air at ordinary pressure and temperature is about 140,000 foot-pounds in each cubic yard of air. Accordingly, the quiet air within a room twelve feet high, eighteen feet wide, and twenty-two feet long, contains energy enough to propel a one-horse-power engine for more than twelve hours. The store drawn upon naturally by uranium and other heavy atoms only awaits the touch of the magic wand of science to enable the twentieth century to cast into the shade the marvels of the nineteenth."

IT IS ORIGINAL, UNDOUBTEDLY.

The attitude of some electrical contemporaries in matters pertaining to electrical transmission surpasses understanding. Last month occasion was given to refer to the absurd stand taken by a New York journal upon the utility of glass insulators for transmission purposes, and now a still more prominent publication gives a place of honor to a communication to which is given, evidently in thoughtlessness, the serious title, "Proposed Method of Long Distance Transmission." The proposed method, concisely stated, is to insert a transformer having a ratio of 1 to 1, in the transmission line midway between the generating and receiving stations, then, to quote the article itself, "if the current in the first section has a tension of 25,000 volts, the current in the second section will have a tension of nearly 25,000 volts."

The fruits of this suggestion, as the writer presents them, are not disillusionizing, as he states that "it will now be seen that by this method it should be practicable to transmit alternating electric currents over nearly double the greatest distance which they have hitherto been transmitted while using at the transmitting station alternating currents of precisely the same tension, and while using line wire of the ordinary kind. If desirable, the current might be sent over a distance of 150 miles by having two transformers such as I have described. One of these might be placed at a distance of 50 miles and the other at a distance of 100 miles from the transmitting station." It is then suggested that if it is desired to use direct currents, rotary transformers having a ratio of 1 to 1, may be substituted for the transformers.

It has been said that for every electrical condition may be found an analogue in mechanical operations, hence to illustrate the present case it may be well to recall the instance of the embryonic electrician who confidently advanced the original idea that, as the greater the number of Le Clanche cells in a series, the louder the series would ring a bell, why not, after the same manner, connect several steam boilers in series so that extremely high pressures could be generated without imposing additional strains upon the boilers, thus enabling steam engines to deliver greater power?

After the writer referred to has settled upon the best way to connect steam boilers in series—whether fire door to smoke stack, or mud valve to steam dome; or perhaps, after he has concluded that it would be advisable to connect blow-off to furnace—he may be disposed to enlighten the benightment of the electrical engineering world upon the advantage to accrue from the giving of something for nothing: from the barter of a zero for a zero with its rim off.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

STREET RAILWAY PUBLICATIONS.

The event of the year in street railway circles is the annual meeting of the American Street Railway Association, and so vital have the applications of electricity become to a solution of the problems of local transportation, that the annual convention of the street railway men has, perforce, almost developed into a gathering of electricians. Of course, many are the subjects pertaining to street railways that are without electrical import; but the question of paramount importance—that of motive power equipment—cannot be considered without acknowledgement of the fact that electric traction is far in advance of any other system. Its efficiency is higher, it is used more extensively, and it is in greater favor with the public; all of which explains why there is so much of electrical detail to be found in the proceedings of the street railway association.

It is in the two street railway publications, however, that the greatest interest of the electrical railway world centers, and especially superb are these publications at Convention times. This year the Association meets at Boston, and the August number of the *Street Railway Review* is so replete with articles of high literary merit concerning the city of Boston and environs, as to make it prized by the layman, and so elaborated with descriptions of Boston's chief electric railway systems as to make it invaluable to the electrical engineer. This is the more artistic publication of this year's Street Railway Convention numbers, but the regular September number of the *Street Railway Journal*, which has also been made a souvenir of the Boston Convention, is as well, a most unusual publication in size, in typographical appearance, and in the character and quality of its reading matter. Especially meritorious are its leading articles on "Street Railway Conditions and Financial Results in Metropolitan Boston," which is devoted to a financial analysis of thirty-one street railway properties in and about the city of Boston; "The Boston Subway," in which is described in considerable detail the latest plans of the subway and subway stations as finally carried into effect, and the "Proposed New Electric Elevated Railway in Boston," a brief article on the proposed construction.

As a class, the two street railway publications now so prominently before the electrical and street railway public, are incomparably superior to any other trade papers published, and they are simply models of the highest excellence.

* * *

AMERICAN NEWS FROM A FOREIGN SOURCE.

The London *Electrician* quotes Prof. Thompson as stating that "in the United States nearly every gas works possesses, or is erecting, a carbide plant in order to use acetylene gas as an enricher for the coal or oil gas ordinarily produced."

The truth is that, so far as the portion of the United States west of the Rocky Mountains is concerned, if a single, solitary gas works "posseses, or is erecting," a carbide or acetylene plant of any nature other than for the purpose of laboratory experiment, the fact is unknown. Nor is it known that acetylene gas is used as an enricher by any gas works in America.

* * *

TURNING A NEW LEAF.

The Engineer and the *Scientific Machinest*, published at Cleveland, O., have been consolidated and now appear under the name first given. The publication contains considerable of interest and value to those who have to do with steam generation and use, and has also some aspirations in an electrical direction. It is hoped however, that the new paper will early see the wisdom of breaking away from the chronic inclination so long evidenced by the *Scientific Machinest* to "crib" matter from its contemporaries without giving proper credit therefor.

Transportation

RHEOSTATIC VS. SERIES PARALLEL CONROL.

BY PROF. THOMAS GRAY.

In the spring of 1896, a number of experiments were made at Louisville, Ky., by members of the senior class of the Rose Polytechnic Institute, of Terra Haute, Ind., on the relative efficiency of the above two methods of controlling the current flowing through the motors of an electric car. In the rheostat method the motors were in parallel, and the total current passed through a rheostat having a maximum resistance of 4.2 ohms. In the series parallel method, the rheostat was first used with the motors in series, and after the resistance had been cut out the next step of the controller lever threw the motors in parallel, and at the same time put each in series with half the rheostat.

After this, the resistance was cut out, and the two motors left in parallel. The final conditions were thus the same in both cases.

The tests included the measurement by means of an integrating watt meter of the watt hours required to make a round trip of 5.5 miles, the car being stopped forty times during the trip. An autographic record was taken of the variation of activity during the start. The rheostat method gives maximum activity at the initial contact, after which there is a gradual diminution as the car attains speed, combined with the sudden increases as the successive coils of the rheostat are cut out. The series parallel method gives the maximum activity when the motors are first put in parallel, and then after the car has attained a speed of four or five miles per hour. The consequence is, that more of the activity is used for propelling the car, and less in overcoming resistance. There resulted in a comparative economy of from ten to fifteen per cent. under the conditions of the test. The ratio of the work done in starting the car in the two cases, as indicated by the autographic record, was approximately four-fifths. The total weight of the car used was about 15,500 pounds, the watt hours per car mile averaged about 900, and the maximum speed between stops about twelve miles per hour.

Personal

Mr. Theo. E. Theberath is a native of New Jersey, having been born in Newark on November 22, 1863. After finishing the public grammar schools and a two years' course in business college, the subject of this sketch commenced life in the world of business as an apprentice in his father's factory in Newark, where he learned the various trades in connection with the manufacture of saddlery hardware. It was there, in the electro-plating baths, that an acquaintance with an application of electricity was first had, and this acquaintance has, during the succeeding years, grown to be so intimate that today Mr. Theberath has already earned the justly deserved distinction of being one of the best electrical engineers that has entered the electric power transmission field.

But to revert to his earlier life: Several years were spent in the saddlery hardware factory, when his father gave young Theberath the choice of getting a better education, or of continuing in the saddlery hardware business. This resulted very quickly in his entering the Stevens Institute of Technology, from which he graduated as mechanical engineer in June, 1888. Six months were then spent as assistant instructor in experimental mechanics at Stevens Institute, when, in November, 1888, Mr. Theberath entered the service of the United States Electric Lighting Company, of Newark, N. J., as detail draughtsman. On February 1st, 1889, the United States Electric Lighting Company was absorbed by the Westinghouse Electric and Manufacturing Company. Under the new management, however, the services of Mr. Theberath were retained in the draughting room until April of the same year, when he was placed in charge of the testing department of the Newark factory of the Westinghouse company. A great deal of practical knowledge was obtained in this position in the ensuing four months, the expiration of which was followed by a transfer to the laboratory with general charge of the testing department and all special work of the outside construction department. Some of the work coming under the head of "special" was the installation, in June, 1890, of the first two large generators for the Pittsburg Reduction Company, of Pittsburg, for the reduction of aluminum. This installation consisted of two generators, each having a capacity of 2500 amperes at 60 volts, and, being run in multiple, they delivered a current of 5000 amperes. This was the beginning of the great plant now operated at Niagara Falls by the Pittsburg Reduction Company for the reduction of aluminum.

THEODORE ERNEST THEBERATH.

In February, 1890, Mr. Theberath was engaged in the installation of several Westinghouse plants to operate coal-cutting machinery in the soft coal mines in West Virginia. In August, 1891, he commenced the installation, which he completed within a few months, of the electrical apparatus for the concentration of magnetic iron ore at the mill of the New Jersey Magnetic Concentrating Company, located in the Adirondack mountains, in New York state. This work, in connection with the wide range of experimental work constantly under way at the laboratory, resulted in Mr. Theberath becoming possessed of information and experience of unusual value along technical lines, so that when Mr. Jno. F. Kelly, who was then chief electrician of the Newark branch of the Westinghouse Company, resigned that position in December, 1891, Mr. Theberath was appointed to the vacancy. During the nine months that Mr. Theberath held the chief electricianship of the Newark branch, his time was largely occupied in designing special generators and crane motors.

Believing that the commercial side of the electrical industry extended greater advantages than the engineering side, Mr. Theberath resigned from the chief electricianship of the Newark branch of the Westinghouse company on October 1st, 1892, and immediately entered the employ of the Ansonia Electric Company, of Chicago, as special sales agent for Stanley transformers. On the dissolution of the Ansonia Electric Company, in October, 1893, he entered the service of the Weston Electrical Instrument Company in charge of the standardizing department, where he remained for nearly a year. On August 1st, 1894, he resigned this position to become associated with the New York office of the Stanley Electric Manufacturing Company as engineer and salesman. Just two years thereafter—August 1st, 1896—he was transferred from the New York office to the Pacific Coast agency of the Stanley company at San Francisco, where he will probably remain permanently. Mr. Theberath first came prominently before the electric transmission interests of the Pacific Coast through his electrical engineering services for the Stanley agency in the construction of the transmission plant of the Blue Lakes Water Company, and more recently as electrical engineer for the Yuba Power Company's transmission to Marysville. His paper on "Lightning on Transmission Lines," read before the Sacramento convention of the Pacific Coast Electric Transmission Association, is one of the most able papers ever brought before that body.

Mr. Theberath's chief characteristics are thoroughness and untiring intensity of purpose. He is a close student, a hard worker, and every inch an engineer. More than this, those who are so fortunate as to be numbered among his personal friends—and they are many—will all attest with one accord that "Theby" is among the nobility of charming fellows.

Prof. F. B. Crocker, past president of the American Institute of Electrical Engineers, president of the Crocker-Wheeler Electric Company, and an electro-technical author of note, was among the recent prominent electrical visitors in San Francisco.

Mr. W. L. Honnold, of San Andreas, Cal., is to act as manager of the Thorpe Gold Mining Syndicate, at Fourth Crossing, Calaveras county, and will also continue to have charge of the properties of the California Exploration Syndicate, Ltd., with which he has been connected as superintendent for the past two years.

Prof. Alexander Graham Bell, inventor of the Bell telephone, recently passed through San Francisco en route to Japan and the Orient, and it is probable that he will continue his pleasure trip around the world.

Mr. A. P. Breyton, Jr., vice-president and manager of the Pelton Water Wheel Company, has sailed for a three months' trip to Japan and the Orient.

Mr. P. F. Morey, president of the Portland, Or., General Electric Company, recently visited San Francisco.

Transmission

MOISTURE ON HIGH TENSION INSULATORS.

BY LIEUT. W. STUART-SMITH, U. S. N.

An editorial appearing in the August issue of The Journal of Electricity relative to insulators for high tension lines, and the discussions constantly taking place as to the effect of the hygroscopic quality of glass, impels me to an expression of opinion on the subject. The editorial referred to states: "While, as far as we know, it is yet to be demonstrated that static electricity exerts any appreciable influence on the temperature of transmission insulators towards the dissipation of moisture that may accumulate thereon, it is well understood that the presence of high tension current on the line tends to preserve its insulation resistance."

To be sure, we must have forgotten our early lessons in electricity that we do not realize that the tendency of an electric charge is to prevent the accumulation of moisture on the surface of a charged body and that this tendency is enormously increased with increasing potential.

Don't we remember that so-called "like" electricities repel, and that on any conducting body, a static charge will only be found on the surface — as far from the center as possible; *i. e.*, it will divide itself over the greatest possible surface, thereby causing the tension to become a mininum? Don't we remember that, in a moist atmosphere, it is impossible to maintain a static charge on a body, not because (as is frequently said) the air is thereby rendered a better conductor and the charge passes through it as through a conducting medium, but because moisture, condensing on the surface, forms a new and easily disintegrated surface which the charge occupies because it is of larger area than that formerly occupied?

Right here some one may say, "What has this to do with the matter? The surface of the insulator is not conducting." This is true as long as it is dry, but as soon as moisture condenses to even the smallest extent, it becomes a conducting surface.

The presence of the charge and the tendency to increase the surface area to the largest possible extent, result in a repulsive force between the neighboring water molecules, and if the electric tension is such that this repulsive force between molecules is greater than the forces binding them to each other, they will fly off into the surrounding space, each taking with it a quantity of electricity depending upon its surface. The action will continue until equilibrium is restored between the forces of repulsion and resistance to molecular separation. If the electric charge causing the surface tension is not renewed, the action will very quickly cease, but if constant renewal of the charge takes place, the action will continue until every vestige of moisture disappears. As such constant renewal takes place when the charged surface is that of an insulator carrying a high tension line, it is evident that when the potential of the line is very high, as is the case with modern transmission lines, any moisture present when the potential is applied to the line will quickly disappear, and any further accumulation will be impossible, since dissipation will take place as fast as there is any condensation. The force of repulsion, and hence the rapidity of dissipation, will increase with increasing line potential, and the hygroscopic quality of the surface will practically be nullified when the tension is a little greater than that necessary to produce a rapidity of dissipation equal to the rapidity of condensation. For any given insulator surface, this will depend upon the hygrometric condition of the atmosphere, but with the high potentials now in use for transmission lines, it is probable that no surface will condense moisture as fast as the force of repulsion can dissipate it, even in a fog.

This being the case, the character of the surface is practically immaterial, and glass is at no disadvantage on account of its inherent power of condensing moisture. Its hygroscopic power may be ignored when very high tensions are carried.

The editorial mentioned, states near the close, that the drying is due to the heating action of the static charge, but in reality the drying is the result of the tendency of the charged surface (in this case a film of moistere) to expand indefinitely. The closing statement is that the action is remarkable. So it is; yet it is a natural consequence of previously well known laws of static charges.

THE MECHANICVILLE-SCHENECTADY TRANSMISSION.

The development of the power of St. Anthony's Falls, on the Mississippi, at Minneapolis, Minn., is followed closely by the utilization of the power of the upper waters of the Hudson river at Mechanicville, N. Y., where an undertaking of no less magnitude has been completed within the past few days. From five to seven thousand horse-power is available at the power house, and the use of high tension current permits of its distribution over a wide territory.

As in the Mississippi, the waters of the Hudson above the present point of development have been to some extent employed by factories using low head turbines for driving their machinery direct, but not until the undertaking just concluded was decided upon had any very serious effort been made to take advantage of the great amount of power which has run to waste for ages down the stream of the main waterway of the Empire state.

It was early in 1897 that the attention of Mr. R. N. King, of Dayton, O., was drawn to this water power, and his long experience with water powers and their development led him speedily to recognize the possibilities which here lay ready to hand. The site is only two miles from Mechanicville, eleven miles from Troy, and eighteen miles from Albany, in each of which towns large amounts of power would, without doubt, find a market. But most important of all, it lay only seventeen miles from Schenectady, where, covering not less than 130 acres of ground, the largest electrical works in the world are operated from an extensive steam plant with which the electrical power from the Mechanicville cataract could readily compete. As a result, and after consultation with the chief engineers of the General Electric Company, in which the necessary assurances were given, Mr. King formed the Hudson River Power Transmission Company.

The hydraulic engineering features of the development were carried out in their entirety by Mr. A. C. Rice, chief engineer; and it may be said that in the complete work as it stands today, little or no departure from the plans laid down by Mr. Rice has been made. As the General Electric Company was to purchase the largest amount of power, its advice as to the electrical equipment was naturally closely followed. The result brought about by the harmonious co-operation of both hydraulic and electrical engineers is a power transmission plant which is in every respect strictly representative of the most modern hydraulic and electrical practice.

At the point chosen for the hydraulic development, the physical conditions make the location an ideal place for a dam and power house. The banks and bottom of the river are of rock, as is Bluff Island, which divides the Hudson into two channels; and here, during the greater part of the year, is water sufficient to produce from 7000 to 10,000 horse-power. The island is about one-third of the distance across the river from the western bank, the combined width of the two channels being about 1200 feet. The western channel is used for the head and tail races.

In order to make the excavations for the power house and main dams, heavy cofferdams were built across both streams. The work would have been well completed within the time at first specified had not an extraordinary freshet swept away part of the cofferdam, necessitating long delay before work could be resumed. The rock and shale proved unsuitable for incorporation into the concrete for the dams and foundations, and the broken rock used was brought over a special track from the neighborhood of Schenectady.

The power house starts from and extends out into the river about 215 feet, and is connected with Bluff Island by a concrete dam, twenty-six feet high above the bed of the river. It is ten feet wide on top and eighteen feet wide at the base. The upstream face is vertical and the down stream face is sloping. The top of this dam is at an elevation that the water will never reach, thus, no provision is made to take care of falling water on the down stream side, but the dam is provided with four arched waste gates four feet wide and six feet, nine inches high, operated in the same manner as those in the main dam.

FIGURE 1.—THE POWER BEFORE DEVELOPMENT.

The main dam is on the eastern side of the island. It is built entirely of concrete, as indeed, is the entire construction with the exception of the upper walls of the power house. The upstream face is vertical, the downstream face is curved and provided with a horizontal apron fourteen feet wide, which throws the falling water off horizontally, and thus effectually prevents wash or scour of the toe of the dam. The dam is sixteen feet high above the river bed, eight feet thick immediately through the crest, sixteen feet thick through the base, and thirty feet thick through base and apron. The dam is set between massive abutments anchored to the rock sides of the river bank and island. The eastern abutment is twenty feet long, twenty-six feet high above river bottom, sixteen feet thick at the top and thirty-four feet wide at the base; the western abutment is one hundred feet long, the other dimensions being similar to those of the eastern abutment. The length of the spillway between abutments is three hundred feet. In the western abutment are twelve arched waste gates of ample proportions. Each gate is four feet wide and six feet high, and is opened and closed by a heavy iron hoist operated by rack and pinion. The eastern dam is practically a solid rock wall capable of resisting any flood. It was severely tested in the spring of 1898 when a flood of extraordinary proportions came against it; yet, notwithstanding the fact that the dam was green, the flood in no manner injured it. To prevent any floating rubbish, ice, or logs reaching the rocks or choking the waste gates, a floating wooden boom stretches from the western end of the spillway diagonally for a distance of four hundred feet, to the edge of the normal river bank, and then for a distance of one thousand feet to the main embankment of the Mechanicville highway. It is anchored to a line of stone filled cribs. Between the west end of the power house and the Mechanicville highway a broad roadway has been built of earth and slate rock. To avoid any possibility of water finding its way through the embankment in case of very high water, a concrete core was put in the center, starting at the solid rock and finishing two feet below the surface of the road. The embankment forming the roadway is forty feet wide on the top, 124 feet at the base, and 18 feet high at the deepest point. The power house lies between the west bank and the short concrete dam, nearly filling the space between the island and the west bank of the river. It is practically a continuation of the dam, and, like the main dam, is of concrete with the exception of the upper walls. Its construction is of the most substantial character, the foundations are carried down to the bedrock, and the house is carried on heavy steel box web girders resting upon steel I beam columns. The latter are imbedded in concrete walls carrying arches which form the floor of the generator room and the floor on which the wheel flumes rest. The walls form a separate and distinct tail race twenty-two feet wide for each set of turbines from which the water may be shut out at will.

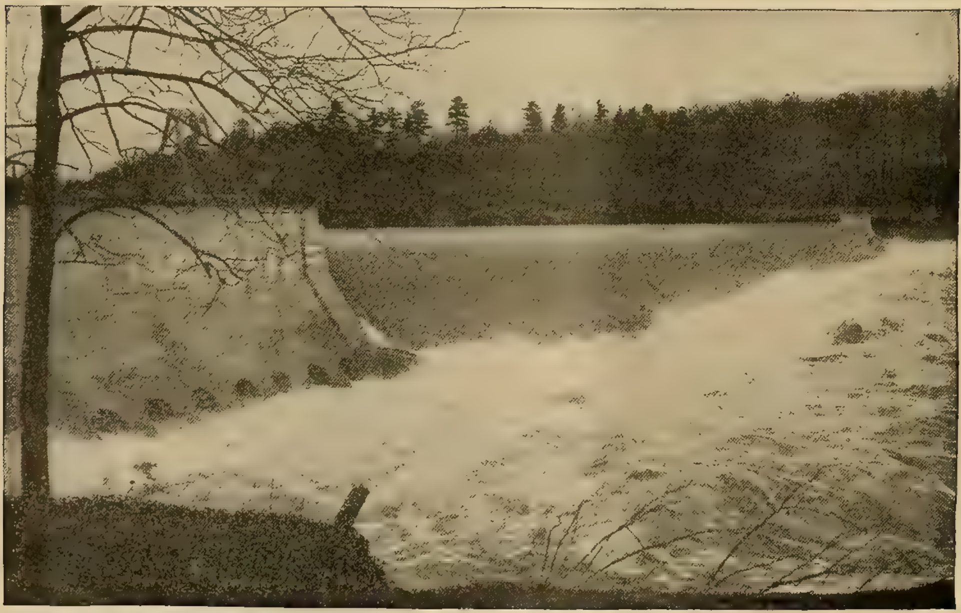


FIGURE 2. MAIN DAM AND WASTE GATES.

The house is divided into two parts by a thick head wall. The upstream part contains wheel chambers for seven 1000 horse-power wheels, of which five only are at present occupied. The downstream portion contains the wheel governors and the electrical apparatus. The length of the power house proper is 257 feet, 6 inches; the width of the dynamo room between head wall and south wall is thirty-four feet, and the width of the wheel chamber portion is thirty-two feet, six inches. The total width of the power house is sixty-six feet, six inches. At the western end an L entension runs upstream eighty-seven feet, five inches long and forty-four feet, ten inches wide. This portion of the power house is of brick. A retaining wall runs down stream from the power house along the western bank a distance of fifty feet. The western stream running between the bank and the island forms the forebay, three hundred feet long. The main tail race is 205 feet wide, and joins the main stream 750 feet below the power house.

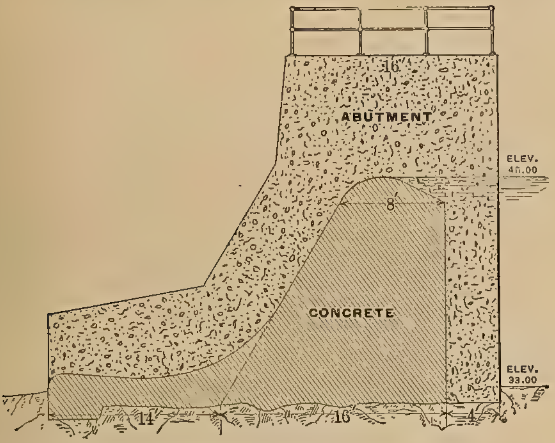


FIGURE 3.—SECTION THROUGH MAIN DAM.

Arched chambers are provided for seven main wheels and two exciter wheels. Each main chamber is thirty-two feet, six inches long, twenty-two feet wide, and seventeen feet five inches high, and is provided with two six-foot manholes. Each exciter wheel chamber is thirty-two feet, six inches long, seventeen feet, five inches high, and ten feet wide. The head wall of the chambers is six feet thick; the wall on the upstream and on both sides is three feet thick. In the head wall of each main chamber is set a heavy cast-iron cover through which the turbine shaft passes in a water-tight packing box, carrying the ring oil bearing for the shaft. The saving in space effected by the new arrangement of housing and coupling together of the turbines has tended to diminish considerably the size of the power house. A twenty-ton crane runs the entire length of the dynamo room.

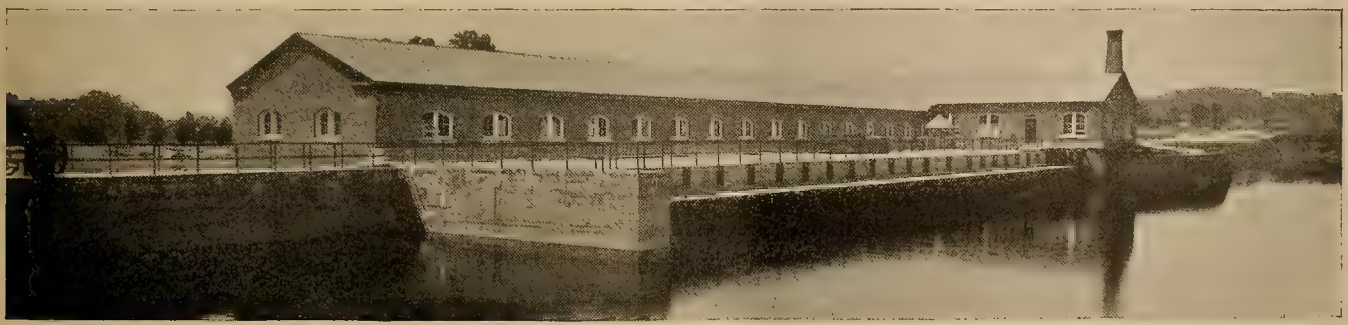


FIGURE 5.—UPSTREAM SIDE OF POWER HOUSE WITH FOREBAY.

In front of the wheel chambers, and running the entire length of the power house, is a trash rack of steel bars supported on a framework of steel channel and I beams. This rack effectually prevents the access to the wheels of any rubbish or floating material that may escape the boom.

The main wheel plant consists of ten pair of forty-two-inch horizontal turbines, each main turbine consisting of two pair of wheels, which at the normal speed of 114 revolutions, is rated at 250 horse-power. The total power of each set of turbines is, therefore, 1000 horse-power. Five units are now in position; the two additional turbines will be installed shortly. The head under which the water wheels are operated is eighteen feet.

The turbines for the exciters consist of three eighteen-inch cylinder gate wheels, having, at 259 revolutions per minute, a total of 300 horse-power. The quarter turns and packing boxes of these wheels are brought through the wall beneath the station switchboard.

Two draft tubes lead from each main turbine, the forward tube descending straight into the tail race beneath the power house, the rear or upstream tube curving and flaring downward and outward. Each tube is nine feet, six inches in diameter at the bottom. Two draft tubes are also allotted to each set of exciter wheels, the setting following a similar arrangement. The rear tube is four feet in diameter and the forward tube three feet.

The speed of each set of main wheels is regulated by an electro-mechanical governor, mounted on a platform directly over the turbine shaft, and between the head wall and the generator.

The use of electricity renders the mechanism of this governor extremely sensitive and effective, and the gates can be entirely opened or shut, should the full current be thrown on or off, in six seconds. The driving pulley is replaced by a rawhide pinion giving a rigid connection between the governor and the wheel, and making 400 revolutions per minute. The speed may be increased to shut off or throw on in less than six seconds, if necessary. The governor is the same as that now in use in many of the most important electric power transmissions in this country, including those of Columbia, S. C., Polzer, N. C., Lachine, Que., West Kootenay, B. C., Montmorency, Que.

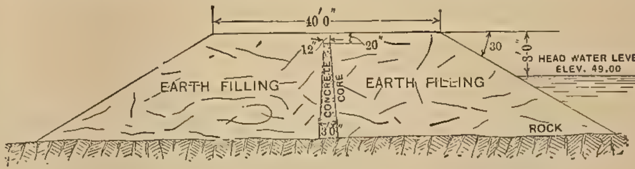


FIGURE 4.—SECTION THROUGH EARTH EMBANKMENT.

The governors controlling the exciter wheel gates rapidly bring the speed to normal when changes are neither frequent nor heavy. They are especially adapted to the regulation of water wheels driving exciters, and are provided with adjustable stops which limit the hoisting action on the gate as soon as the gate is fully open.

The dynamo room is a spacious chamber well lighted by windows on all sides. It is 255 feet long and 34 feet wide, 30 feet, 5 inches in the clear from floor to roof truss, and 22 feet from floor to crane. The ultimate generator capacity of the station is 7000 horse-power in seven generators, each of 750 kilowatts capacity, of which five have been installed and are now running. They are unitooth, three-phase, forty pole, 750 kilowatts, 114 revolution, alternating current machines, having revolving fields and stationary armatures, and wound to deliver thirty-six amperes of current at a periodicity of thirty-eight cycles and a pressure of 12,000 volts to the transmission lines. They are arranged for operation in parallel at constant voltage. By using the revolving field type of generator and thus securing this pressure directly from the machine, the use of step-up transformers to raise the voltage for transmission purposes is avoided. As the current is to operate synchronous and induction motors, to operate lights, and to be converted into direct current through rotary converters, a frequency of about 40 cycles was selected as most suitable for the different conditions required.

The alternators are similar in their main characteristics to those successfully used in the development of the power of the Lachine Rapids at Montreal. The armature frame or ring is of the box type, fifteen feet, four inches in diameter, and thirty-six inches wide. It is bolted to a base eighteen feet, two inches long by ten feet wide, along which it may be moved parallel with the shaft, in order that the revolving field spider and poles may be uncovered should occasion arise. The armature winding is protected on each side by iron shields. The pillow blocks are also bolted to the base and the bearings are of the spherical seated self-oiling type used in all General Electric generators.

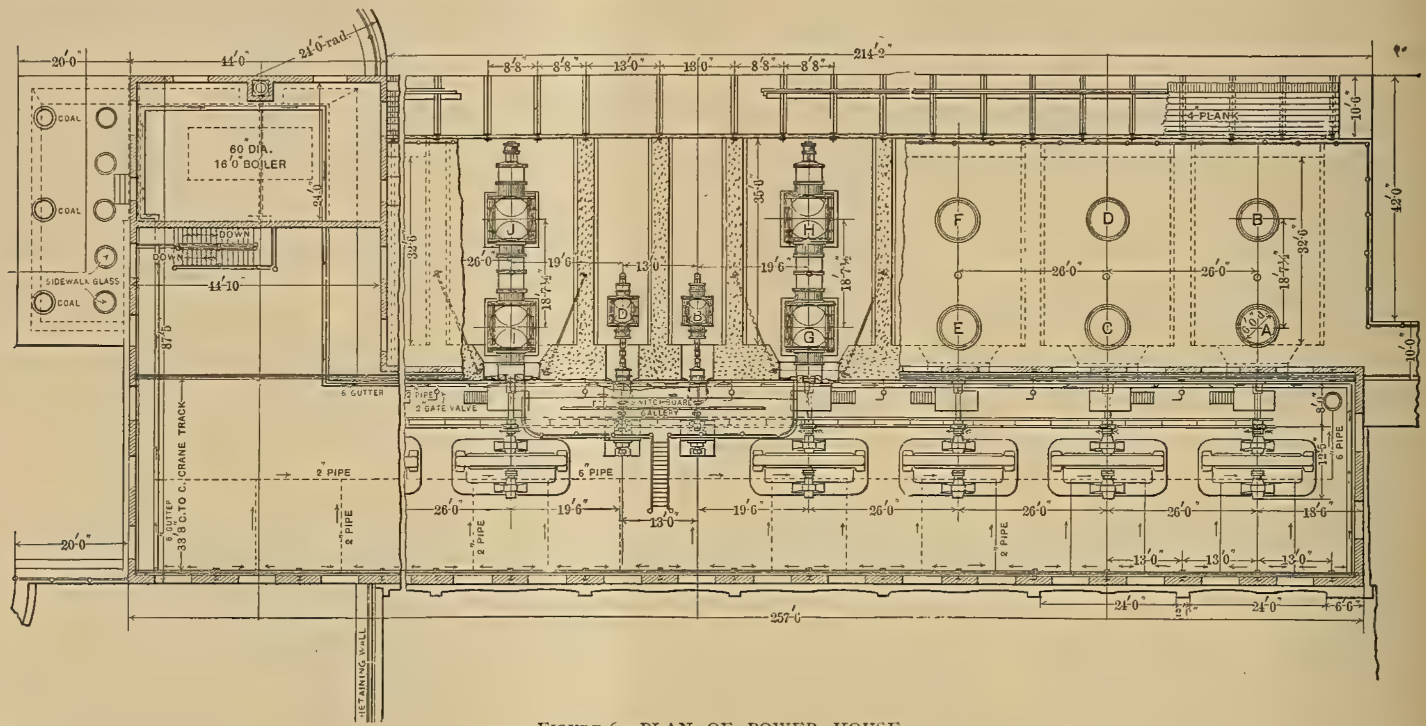


FIGURE 6.—PLAN OF POWER HOUSE.

The field ring is bolted to the spokes of the spider. It carries forty poles, each securely fastened by two bolts to the ring. The whole revolves on a shaft fifteen inches in diameter, provided with a rigid coupling on the turbine side bolted to a similar coupling on the turbine shaft. The dynamo shaft is entended for coupling to a vertical steam engine in case of necessity.

The reasons for selecting this type of alternator are given by Mr. C. P. Steinmetz, of the General Electric Company, as follows: In addition to the advantage which the stationary armature type has over the stationary field type in allowing a high transmission voltage to be taken directly from the armatures, it allows of a fairly low saturation of the magnetic circuit giving an almost straight saturation curve. This is preferable in power transmission, since a considerable increase in the voltage may be obtained if needed to cover excessive drop in the lines due to heavy loads, and the voltage may be maintained even if the speed remains low.

The exciters are placed one on each side of the stairway leading to the switchboard gallery. They are six pole, 100 kilowatt, 125-volt standard General Electric machines, with ribbed field frame and iron-clad armatures.

The switchboard erected on a gallery on the north wall of the dynamo room, is built up of nine highly polished panels of blue Vermont marble, each panel seven feet, six inches high, three feet wide, and two inches thick. Of these nine panels, five are used for the generators and two for the feeders; one is the total output panel, and the last is for the control of the exciters. The generator panels occupy the left side of the board, and room on the gallery is left for two additional panels. The feeder panels are on the right side; the total output panel is between these and the generator panels, and the exciter panel is the third panel from the left hand end of the board.

Each generator panel is equipped with the following instruments: One inclined coil alternating ammeter reading to 75 amperes for the generator, and one direct current ammeter reading to 150 amperes for the field. Above each of these is a pilot lamp and between each pilot lamp a synchronizing lamp. Beneath the two ammeters is an inclined coil voltmeter reading to 15,000 volts, and beneath this instrument are three single blade, doube throw, quick break, high tension switches, each mounted upon pyramids of corrugated hard rubber. Similar periods intervene at the back of the board between the 'bus bars and the board. The corrugations give a total distance of about eight inches of surface between the metal clips and hinge and the surface of the marble on each side. As these are to break current of 12,000 volts, they are tested to break without difficulty currents of 21,000 volts. The switches are without handles. An eye is made in the end of each blade into which a hook at the end of a stick may be inserted and the switch opened by the attendant from a safe distance. Further, to prevent any dangerous arcing from blade to blade, marble barriers one and one-quarter inches thick, three inches long, and twelve inches wide from the face of the board are erected between each blade. On the left hand side of each generator panel sub-base are two one hundred ampere double pole, double throw carbon break switches—one the field switch, the other the lighting switch. On the back of the panels are the high tension fuse blocks.

These fuse blocks, designed for 20,000 volts, are of the snap break expulsion type. They are mounted on pyramids of corrugated hard rubber, which contain copper spring contact clips, between which two copper blades enter, connecting the fuse block to the line. The aluminum fuse is held tightly between two arms which are movable around a pivot, and may be pulled apart by two strong spiral springs encircling this pivot. As soon as an increase of current in the line melts the fuse, its two halves are instantly pulled apart, and thus the formation of an arc between the two halves is prevented. The melting of the fuse can only occur in a small chamber protected by wooden blocks. The whole device is covered by two vertical wooden boards. Sliding in between these wooden boards in vertical slots, are fibre shields intended to prevent arcing over between the two arms after the separation of the two halves of the melted fuse. The two wooden blocks and fibre shields are held in position by four screws. The whole fuse block is inserted in the line simply by pushing the two blade-like copper contacts between the clip contacts, which are connected by solid copper rods to the 'bus bars. The wooden boards protecting the fuse are 10½ inches long by 6⅔ inches wide. The corrugated rubber pyramids on which the contacts are mounted are 3½ inches high. The field rheostats are hung beneath the gallery, and are operated by hand wheels on the gallery and bevel gears below it.

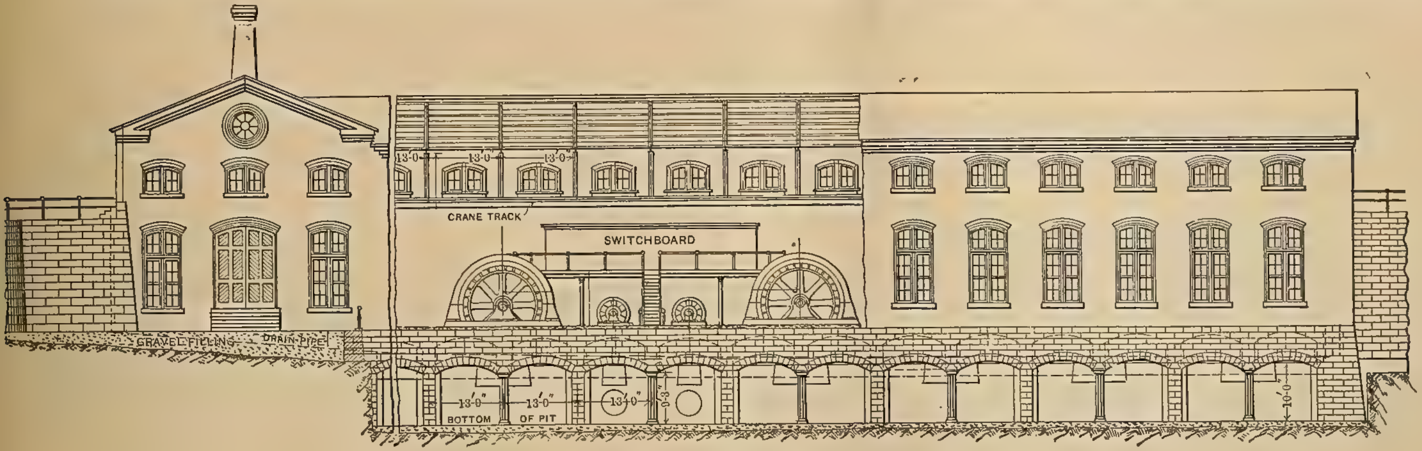


FIGURE 7.—SIDE ELEVATION OF POWER HOUSE, LOOKING UPSTREAM.

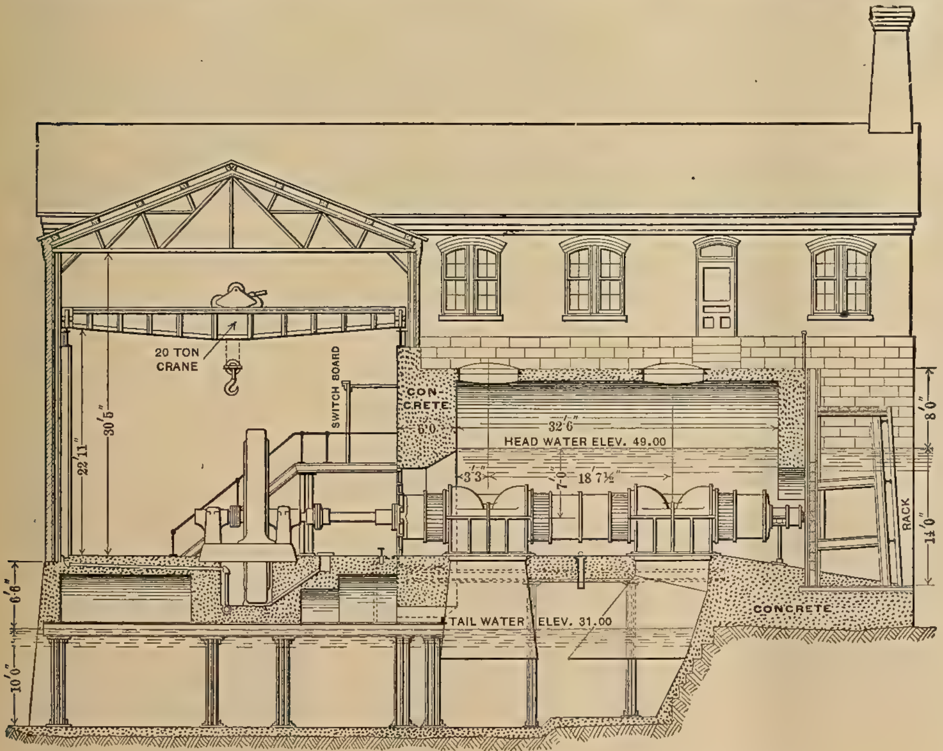


FIGURE 8.—SECTION THROUGH MAIN WHEEL CHAMBERS.

The exciter panel controlling the two direct current exciters carries two pilot lamps, two circular dial ammeters, each reading to 1000 amperes, one volt-meter reading to 150 volts, one four-point pressure switch, one synchronizing switch, two 800 ampere triple blade, double throw equalizer switches, and two packed card rheostats.

The two feeder panels are similar to each other in every respect. Each outgoing line is provided with an independent ammeter, reading to 150 amperes, and a quick break, double throw, high tension switch, similar to those on the generator panels, and similarly mounted on the board. Mounted also on corrugated hard rubber pyramids are the six circuit breakers or automatic plunger switches.

These high potential plunger switches consist simply of long copper rods sliding in hard rubber tubes. The upper ends of the rods reach into small rings in contact with which they are held by a lever catching a small rubber head on the lower end of the copper rod. This lever is held in place by a spring and is released by moving a rocker arm on the back of the switchboard. The moment it is released a spiral spring pushes the copper rod downward, and by this movement, aided by the action of gravity, so suddenly is the contact broken that arcing between the rod and the ring is prevented. The rocker arm controls the three switches for each set of 'bus bars, so that they may be all released at once. On the upper part of each feeder panel at the back, is a current transformer for each outgoing line, two recording single-phase wattmeters, each reading to twenty-five amperes and 12,000 volts, and two potential transformers. On the front of the output panel are two Thomson recording wattmeters for balanced three-phase circuits, each reading to 300 amperes and 12,000 volts, and twelve triple pole, single throw 100 ampere switches with fuses for the lighting circuits. On the back are four potential and two current transformers. The lightning arresters are of the GE. short gap type. Arresters of this type have been installed on nearly all of the most important long distance transmission lines in this country, and have proved a most satisfactory protection against damage by lightning. The principle on which this arrester operates is very simple. It allows the passage of any high potential discharge, but effectually prevents the alternating current from following and maintaining an arc. The gap spaces in the lightning arresters at Mechanicville are very small — about $\frac{1}{32}$ inch — each space lying between two solid metal cylinders two inches in diameter and two inches long. A low non-inductive graphite resistance is placed on the circuit, and the action of the arrester, therefore, is dependent upon the cooling effect of the large metal cylinders, aided by the reversal of the alternating current and the introduction of the non-inductive resistance. The line is protected by double pole 2000 volt arresters, connected six in series to give the necessary number of spark gaps. There are three sets of these. One at Mechanicville, grouped around the first transmission pole in a small house fifteen feet square, one set on the Schenectady side of the Glenville bridge, where the overhead pole line connects with the underground cable, and the third at the works.

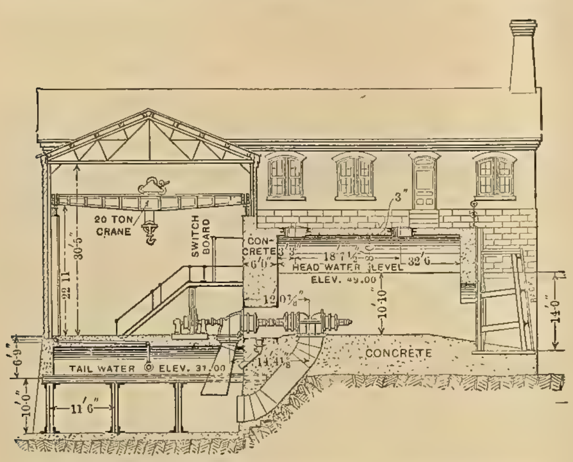


FIGURE 9.—SECTION THROUGH EXCITER WHEEL CHAMBERS.

The lead covered leads from the generators are taken out at the base of the machine and are laid in ducts in the floor. Rubber covered wire is used for the field connections. The cables rise on a frame from the duct to the floor of the gallery through which they rise to the board. From the back of the board the line wires rise to supports bolted to the I beam on the north wall, which supports one of the crane runways. The lines run along the north and west walls and pass out to the poles through a blind window over the door of the power house.

The line from Mechanicville to Schenectady is the only one at present laid down. It consists of three No. 000 B. & S. bare wire, this large gauge being employed in order to give the line as high self-induction as possible. This insertion of self-induction in transmission lines is a departure from earlier practice. In cases where synchonizing apparatus is used, self-induction is now considered necessary, and is artificially brought into the line in the shape of reactive coils in cases in which the natural self-induction is too small. The circuits are carried on poles thirty to sixty feet long, and all eight inches in diameter at the top. Each pole carries one cross arm, on one side of which are two porcelain insulators of the triple petticoated type, a third being on the other side. For lightning protection, a barbed wire frequently grounded, runs along the tops of the poles.

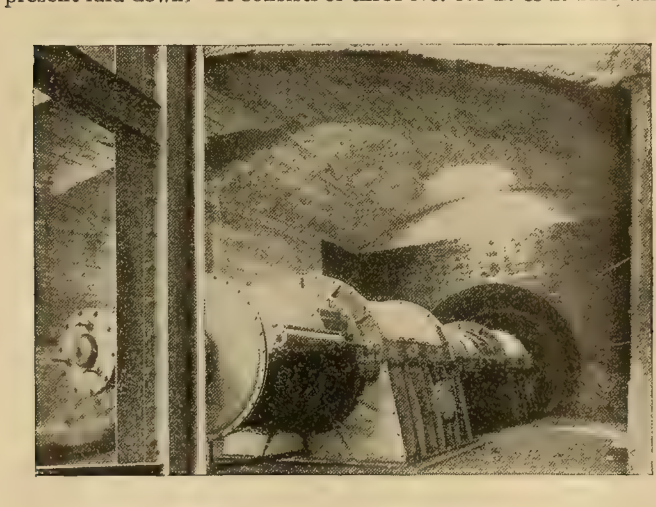


FIGURE 10.—A MAIN WHEEL CHAMBER.

The line takes a westerly direction to East Glenville and then due south to Schenectady. At the end of the Glenville bridge over the Mohawk — the town limits — it is carried down to the ground and connected to three cables of No. 1 gauge stranded copper insulated by one-quarter inch rubber and $\frac{3}{32}$ lead sheet laid in terra cotta conduits. These cables run seventeen hundred feet along Washington avenue, rise to poles again through Rotterdam street to the Erie canal, and along the canal to a point directly opposite the General Electric company's power station. They then cross the canal and enter the works.

The introduction of this transmitted electrical power into the factory will work a considerable change. At present all the machinery is driven by electric motors, while the testing department demands an independent supply of current for the work it carries on. There are at present, therefore, two distinct generating plants. The 550-volt motors in the testing department are supplied from an engine driven multipolar generator of 500 kilowatts capacity, while a smaller engine drives a number of exciters which allow of independent control of the excitation of all machines in this department. The factory is operated by a number of 250-volt motors running on the same circuit as the factory lights. These motors will not be changed, and the steam plant which supplies them will be retained as a reserve. The electric power plant superceding the present steam plant at the works will, therefore, consist of two synchronous motors, one of 500 kilowatts, the other of 100 kilowatts, and three 400-kilowatt rotary converters — the synchronous motors for the testing department, the converters to supply current to the factory motors.

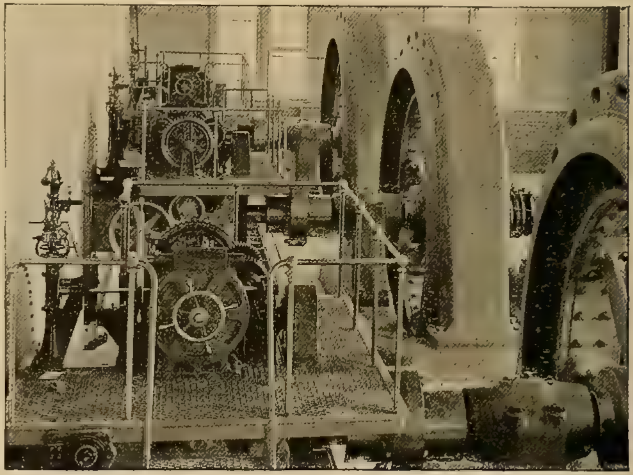


FIGURE 11.—MAIN WHEEL GOVERNORS.

The large engine driving the 500-kilowatt multipolar generator is superceded by the 500-kilowatt synchronous motor. This is a twelve pole, 400 revolution machine of the revolving field type, wound directly for 10,000 volts. The small engine driving the exciters is replaced by the 100-kilowatt synchronous motor, and an eight pole, 600 revolutions per minute revolving field machine, similarly wound. This disposition renders this department independent of everything but the speed of the Mechanicville generators, which will be kept as nearly constant as possible.

The three rotaries supplying 250-volt current to the factory motors, are ten pole, 400-kilowatt, 480 revolutions per minute machines, having two commutators and two sets of collector rings connected to independent windings on the armatures. They receive the three-phase current from independent secondary coils of the same set of air-blast transformers. When connected in multiple they furnish current at normal pressure of 250 volts, but as they may be called upon to furnish current to the testing department in case the demand exceeds the supply from the synchronous motor driven machine, they may be connected in series to give 500-volt current, operating in parallel with the railway generator driven by the synchronous motor in the testing department.

The rotaries are operated in parallel, and all the factory motors, the factory railway, and all the factory lighting on the system is operated from the same direct current circuit. The latter is the Edison three-wire system, the neutral wire of which is secured by connecting the transformers for the rotaries in Y with their secondaries, and bringing to the neutral a lead from their common connection.

Synchronous motors were selected in preference to induction motors on account, first, of their more constant speed and greater efficiency; second, because they do not produce lagging currents. In addition, the phase displacement and power factor may be controlled as desired by means of control of the field excitation.

Synchronous motors of the revolving field type and of good design, are self-starting even under heavy load; and will easily carry two or three times full load without falling out of step for a time limited only by the heating of the motor.

To make the entire works system self-regulating in the direct current distribution, and as far as possible independent of hand regulation, the rotary converters are given a shunt field and a powerful series field, so joined together that the machines operate as one unit. With constant voltage in the generating station at no load, the counter electromotive force of the rotaries as given by their shunt field, is below the impressed electromotive force, and a lagging current is produced. The self-induction of the lines is thus in opposition to the voltage, which is so reduced as to give 250 volts at the commutator brushes of the rotaries. As the load increases, the counter electromotive force of the rotaries rises from the series field, until at full and over-load it is greater than the impressed electromotive force and the current becomes leading. The electromotive force of self-induction of the lines is then brought partly in phase with the voltage which is increased so that in spite of the increased line current, and consequently increased energy loss in the line, with constant generator voltage, the same voltage is produced at the commutator brushes of the rotaries at no load as at full and overload. This control is, therefore, automatic in every way, and did the synchronous motor not take current over the same line in varying quantities, it would suffice. To render this control perfectly automatic, therefore, small series transformers are inserted in the lines leading to the synchronous motor, feeding a small synchronous motor generator controlling the shunt field of the rotaries. By the combined action of their shunt and series fields, the voltage is automatically maintained constant at the commutator brushes of the rotaries, and no hand regulation is required beyond that of readjustment in case the number of rotaries in operation is changed.

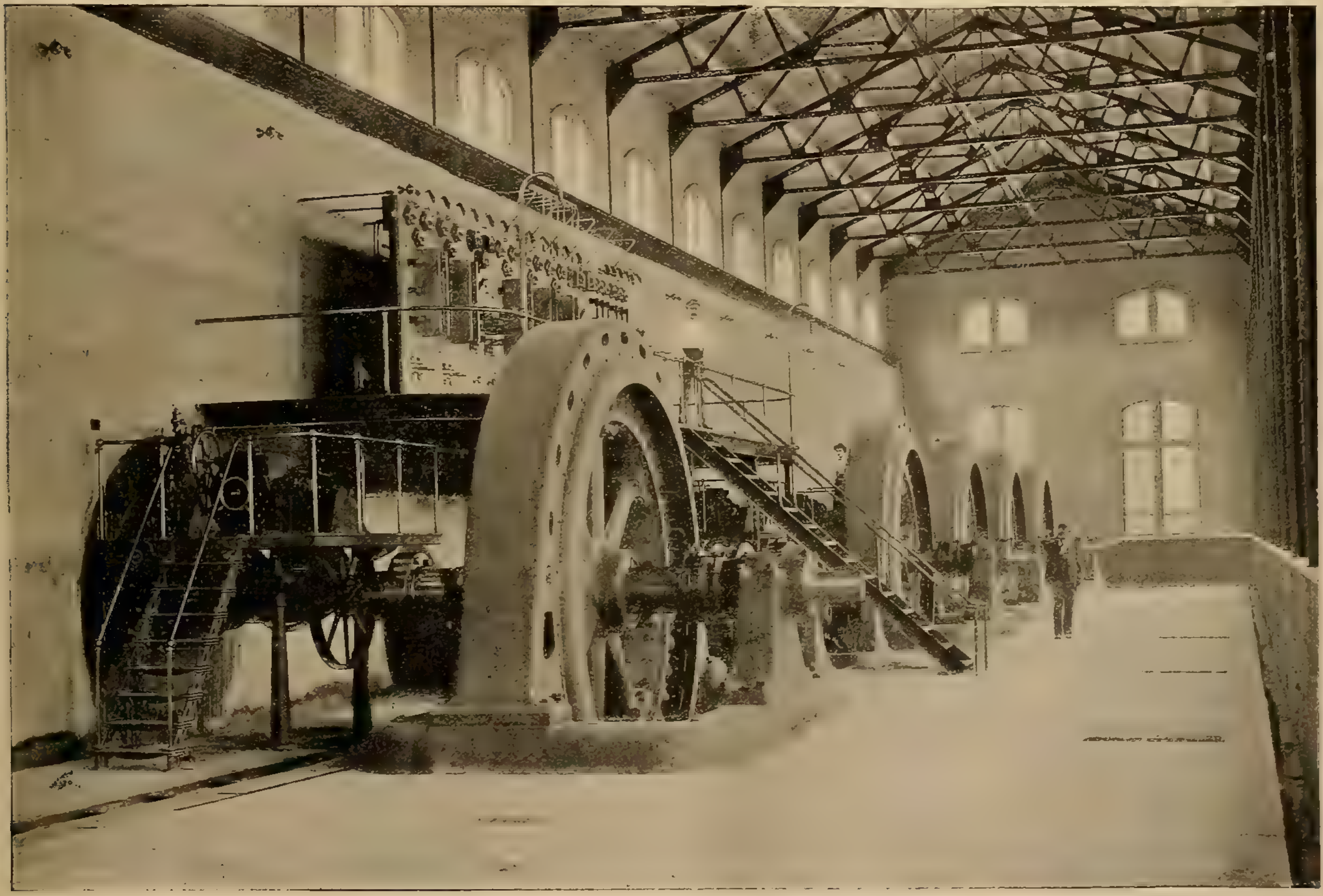


FIGURE 12.– INTERIOR OF POWER HOUSE. DYNAMO ROOM.

The Baltimore and Ohio Railroad is about to indulge in an experiment of using the telephone for long distance communication. Work will begin in a few days on the construction of two new copper telegraph lines between Baltimore and Pittsburg, 340 miles, and they will be so arranged that when the necessity arises they will be available for telephonic communication. One of the wires will be extended as far as Newark for telegraphic use.

A picture of an interesting Baltimore and Ohio Railroad building was reproduced in a recent issue of *Truth*. It is the station at Mount Clare, Baltimore, and it is noted as being the location of the first telegraph office in the world. It was from this building that Professor Morse sent his celebrated message in 1844 to his friends in Washington, forty miles away.

Trade Literature.

(Catalogues mentioned in this department will be mailed gratuitously on application to the concerns publishing them. When writing, mention THE JOURNAL OF ELECTRICITY. Where addresses are not given, they may be found through reference to the Advertisers' Index on page iii.)

A twenty-page pamphlet, illustrated, descriptive of the Morton-Wimshurst-Holtz static machine and accessory apparatus for radiography and the therapeutics of static electricity. Dr. Cyrus Edson's ozone inhaler is also described. *A. E. Brooke Ridley, San Francisco.*

"Lightning Arresters," (No. 9061). An exquisite brochure in two colors, illustrative and descriptive of lightning phenomena, and the means adopted by the General Electric Company to afford protection against it. All kinds of electric service are considered. Thirty pages. *General Electric Company.*

"White Lead, Colors, Paints and Chemicals." A substantial ninety-six-page descriptive catalogue and price list of all materials, chemicals, and ingredients used in paints and painting; in brief, it is a lexicon of the art of painting, and, as such, it appears to be indispensable. *Harrison Bros. & Co., (Inc.) Philadelphia.*

"One Quarter of a Million Horse-power of Polyphase Electric Transmission Apparatus." Essentially a list of the principal electric lighting and power plants using the polyphase apparatus of the Westinghouse company, and aggregating over 306,000 horse-power. Illustrated with various types of apparatus. Twenty-four pages. *Westinghouse Electric and Manufacturing Company.*

"The Hunt Cable Railway for Handling Coal and Merchandise," (No. 9803) and "The Hunt Automatic Railway," (No. 9806). Freely illustrated descriptive pamphlets of eighteen and twenty-four pages respectively, showing the perfection which has been reached in the handling of coal at railway terminal points, or at points of consumption. Testimonials are incorporated. *The C. W. Hunt Co., 45 Broadway, New York.*

A fifty-six page pamphlet illustrating some thirty pieces of work of the nearly 600 contracts executed by the concerns named for railway and highway bridges, piers, docks, dredging and harbor improvements, flumes, dams, pipe lines, coal bunkers, and structural iron and steel work. A very convincing catalogue. The *San Francisco Bridge Company, 42 Market Street, San Francisco,* and the *New York Dredging Company, World Building, New York City.*

"The General Electric Company at Omaha." A neat thirty-two page brochure, fully illustrated, for distribution at the Trans-Mississippi Exposition at Omaha. As all the machinery used to light the grounds and buildings of the Trans-Mississippi Exposition, and to supply the power, was furnished by the General Electric Company, the types of apparatus shown in the brochure enable the visitor readily to identify each type as he meets with it in the exhibit, or in any part of the working plant itself. *General Electric Company, San Francisco.*

A 1000-HORSE-POWER INDUCTION MOTOR.

The municipal pumping station of the city of Geneva is being equipped with a two-phase induction motor from the works of Messrs. Brown, Boveri & Co., of Baden, Switzerland, and having a capacity of 1000 brake horse-power. It is a ten-pole machine, running at 544 revolutions per minute, weighing twenty-seven tons, and supplied with two-phase current at 2500 volts and forty-six cycles. The circuits of the rotor are brought out through the hollow shaft to three contact rings, for the use of a separate starting resistance in the secondary.

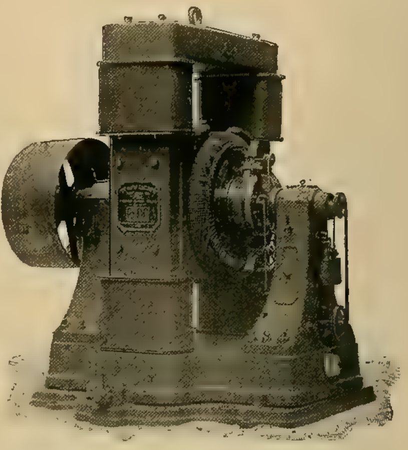
Messrs. Edgecomb and Fox, in a recent paper read before the London Institution of Electrical Engineers, give the following figures for the relative weight of copper for a given maximum voltage: Direct current, 100; single-phase, 200; two-phase, four wires, 200; two-phase, three wires, 291; three-phase, 150.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

THE LATEST FORT WAYNE ARC DYNAMO.

A DECIDED improvement in the efficiency and general qualification of the modern arc lighting dynamo is embodied in the latest machine that the Fort Wayne Electric Corporation has put upon the market, and which is, without doubt, representative of the highest attainment yet achieved in the building of arc machines. It is technically termed the "9 B" arc machine, and it is run at a speed of 725 revolutions per minute, at which it delivers a current of 9.6 amperes at 6500 volts maximum, or 125 lights of 2000 nominal candle power. When wound for 1200 candle power arcs, it is capable of operating 160 lamps successfully. The "9 B" machine will operate on all loads sparklessly; its temperature never rises over thirty degrees above that of the room, which is very low indeed. The weight of the machine is 8343 pounds, the armature alone weighing 1565 pounds, and the dynamo is constructed with reversible regulator and removable field coils. Its efficiency is the highest yet secured in arc machines, for no other arc dynamo can equal the following, which is the record of the "9 B" machine expressed in commercial efficiencies: Full load, 90 per cent.; three-quarter load, 87.5 per cent.; one-half load, 82 per cent.; one-quarter load, 69 per cent.



Further information will be given on application to the San Francisco office of the Fort Wayne Electric Corporation, 18 Second street.

TABLE OF CONTENTS.

Illustrated articles are designated by an asterisk (*); Editorials by a dagger (†); Passing Comment by a double dagger (‡), and Industrial by a section mark (§).

Gas

‡ American News From a Foreign Source.......... 55

Industrial

The Latest Fort Wayne Arc Dynamo.......... 64

Literature

‡ Street Railway Publications.......... 55
‡ Turning a New Leaf.......... 55

Miscellany

† A Look Into the Future.......... 54

Personal
.... 56

Steam

Coal Combustion and Smoke Prevention.......... 51

Trade Literature
.... 64

Transmission

* Building the Tramway Over Chilkoot Pass.......... 49
† It is Original, Undoubtedly.......... 54
Moisture on High Tension Insulators.......... 57
* The Mechanicville-Schenectady Transmission.......... 57

Transportation

Rheostatic vs. Series Parallel Control.......... 55

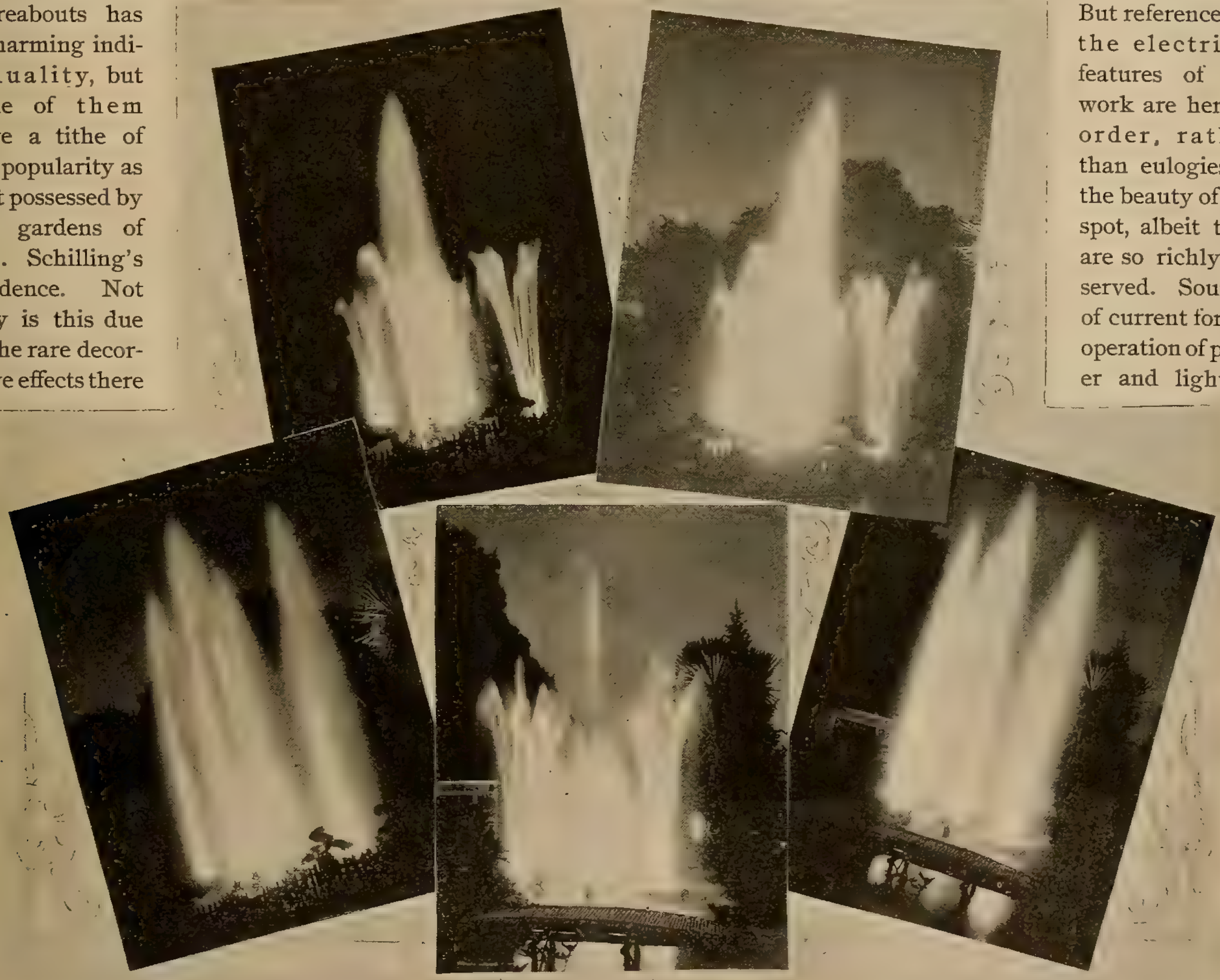
THE JOURNAL OF ELECTRICITY.

VOLUME VI. SAN FRANCISCO, OCTOBER, 1898. NUMBER 4.

Electricity in the Schilling Gardens.

BY R. W. LOHMANN.

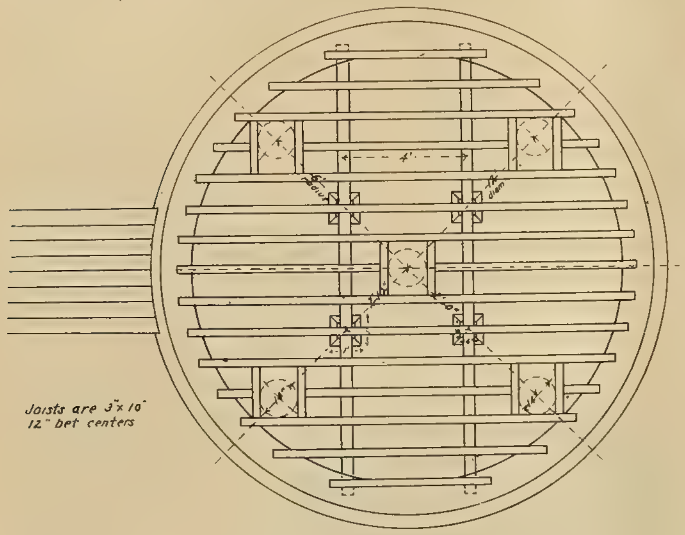
HOW adroitly the skill of the electrical engineer may be blended with that of the landscape gardener is shown in the beautiful private grounds surrounding the home of Mr. A. Schilling, in Oakland, Cal. Each of the many very beautiful residences thereabouts has a charming individuality, but none of them have a tithe of the popularity as that possessed by the gardens of Mr. Schilling's residence. Not only is this due to the rare decorative effects there to be found, but also to the generosity of Mr. Schilling, who, on Saturday and Sunday evenings, throws the illuminated grounds open to the public. It is truly a spot long to be remembered—all quaintly Japanese and most exquisitely illuminated at night with dainty multi-colored miniature incandescent lamps; with its plashing electric fountain, ever changing in form and color; and with its rustic summer tea houses, rendered doubly agreeable by the brilliant notes of large Regina music boxes, wafted thither through underground passages on occasionally perfumed breezes. But references to the electrical features of the work are here in order, rather than eulogies of the beauty of the spot, albeit they are so richly deserved. Sources of current for the operation of power and lighting circuits are found in the 500-volt railway line that passes within a few blocks, and the regular 2000-volt alternating circuit of the Oakland Gas, Light and Heat Company. All motors are, therefore, run at 500 volts; the lighting circuits within the mansion are at 100 volts,



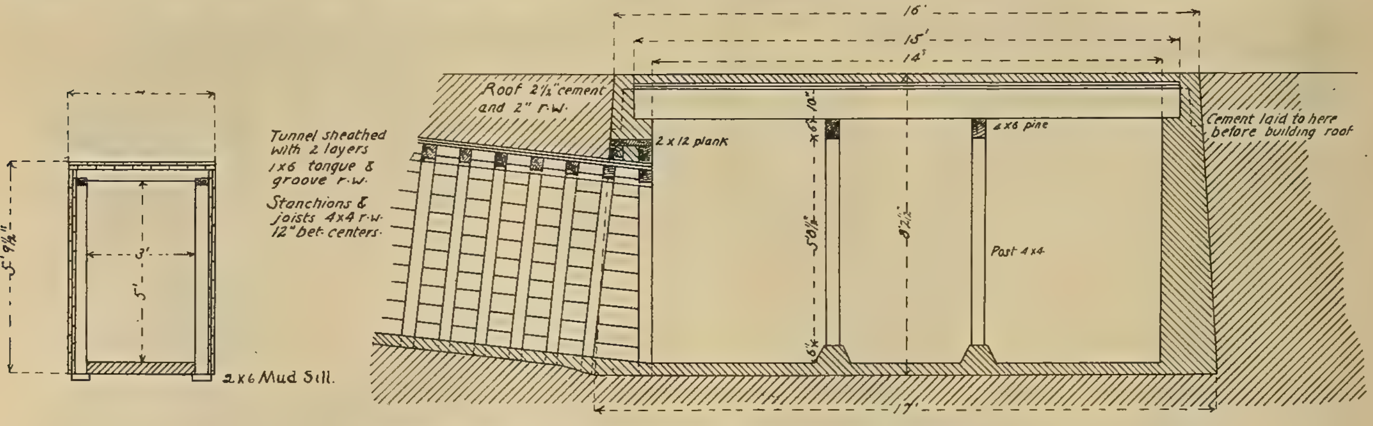
FIVE DIFFERENT JET COMBINATIONS.

ELECTRIC FOUNTAIN IN THE SCHILLING GARDENS.

and those of the grounds are at 50 volts—this lower potential being chosen on account of the difficult conditions under which the wiring had to be installed and operated. The hundreds of minature lamps used are each of three candle power, and they are placed five in series across the 50-volt circuit. As they are 12½-volt lamps, this arrangement increases their life by burning them at a voltage lower than normal. No special rule was followed in placing these miniatures. They are everywhere, being thickly studded so as to make an illuminated ceiling of the wisteria and passion vines that over-climb the verandahs, as well as being placed equally close in the rustic arches that span the footwalks here and there. By day, you see nothing of these lamps; they are smothered in vines and climbing roses, but at night they glimmer out in myriads from most unexpected places—from rocky points, from behind rivulets and waterfalls, from within caverns and beneath the water of the fish ponds, and these effects, amid a garden where the tall palms and the ruddy oaks alike glisten with countless lights as christmas trees, impel one to linger long in their beauties.



PLAN OF ROOF TIMBERS, SHOWING NOZZLE ARRANGEMENT.


16'
15'
14'
Roof 2½" cement and 2" r.w.
Tunnel sheathed with 2 layers 1x6 tongue & groove r.w.
Stanchions & joists 4x4 r.w. 12" bet. centers.
2 x 12 plank
4x6 pine
Cement laid to here before building roof
Post 4x4
10"
5'6½"
6½"
3'
5'
5'9¾"
2x6 Mud Sill.
17'

CROSS SECTION OF OPERATING CHAMBER AND TUNNEL.

The wiring for the garden lighting circuits is all done with lead covered twin cable, which is run under water or imbedded in concrete, or along lattice work, or in the trees and shrubs as may be necessary. Occasionally, sixteen candle power, 50-volt lamps are used in ponds and caverns and in the Japanese iron or wood lanterns in the grounds. The circuits are split up into small groups of lights, each separately controlled by means of switches hidden away at many points throughout the grounds so that any portion may be lighted independently.

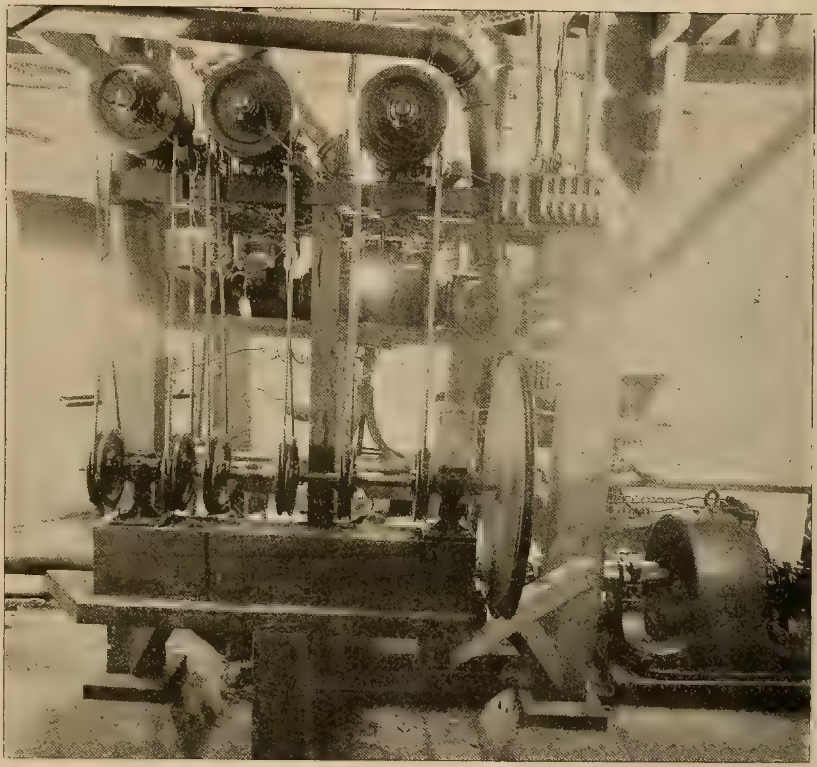
The principal feature of engineering interest is the electric fountain. This was designed and installed by Mr. E. I. Dyer and the writer about two years ago, and full information and working drawings of the fountain are here presented in the belief that they may possibly carry suggestions to whoever may have work of a similar nature to undertake. The fountain is really a small one, as it has a diameter in the clear of but fourteen feet; nevertheless, it appeared much larger when completed, owing to the skill of the landscape gardener in eliminating the outlines of the fountain from sight in the pond. Nothing about the pond suggests the presence of the fountain save, perhaps, the systematic arrangement of the five nests of rock containing the nozzles.

Details of the fountain are given in the accompanying figures, the first two showing the plan and cross section of the concrete and wood work of the fountain, from which it will be seen that the diameter of the circular operating chamber is 14 feet, and that its height in the clear is 5 feet, 6½ inches. The concrete walls are 18 inches thick at the bottom, tapering to 12 inches at the top, and they are well plastered on the inner face to prevent inseepage of water. All woodwork in contact with soil or concrete was thoroughly coated with boiling tar. Joists measuring 3×10 inches were laid on a sill of redwood and imbedded in concrete which was then laid to the dotted line shown in the cross section in the drawing. After the concrete had hardened for two days, two-inch tongued and grooved redwood roofing was laid on, and over this was placed a sheet of lead, 1-32-inch thick, covering the entire roof and enclosing the ends of the joists previously imbedded in the concrete. The five hoods or funnels, and the two ventilating pipes were then bolted directly to the roof, making a water-tight joint with the lead. The sheet lead was then tarred and covered with P. & B. building paper to prevent corrosion, and a mortar of sharp sand and cement was laid to a depth of 2½ inches, thus bringing the roof up to the level of the pond. The experience of the two years that have elapsed since the completion of the fountain is that this construction insures an absolutely water-tight roof, regardless of cracks in the cement due to the settling of the walls, the deflection of the roof, or even of earthquakes. No crib was used during construction to retain the outer face of the wall, as the natural bank of clay was sufficiently hard to withstand tamping, etc. Great care was taken, however, to prevent the clay from mixing with, or falling on the concrete. The inner crib was 1 × 4-inch tongued and grooved redwood, nailed lightly to circular frames. It was only 4½ feet high to facilitate tamping, and when four feet of concrete was laid, the crib was raised sufficiently and the wall was completed. This 1 × 4-inch stuff was later used as sheathing for the tunnel. The roof was designed to withstand the weight of the water above with a large factor of safety, and with small deflection, and without support other than the chamber walls. Some framework, however, was necessary for the switchboard and controlling apparatus, hence the additional supports were erected as shown in the photographic view of the operating chamber. The floor of this chamber slopes toward a drain in the center from which a three-inch pipe discharges into Lake Merritt, ninety feet distant. The size of this pipe is due to the very low gradient of fall. A tunnel and a flight of five steps connect the operating chamber with the basement of the house, situated thirty feet distant from the fountain. This tunnel is 5 × 3 feet in the clear, and is of 4 × 4-inch redwood stanchions and joists, and is sheathed on the sides and top with 1 × 4-inch tongued and grooved tarred redwood. The floor is of cement.

The third and fourth drawings show the plan and cross section, respectively, of the hoods and nozzles. It should be noted that by this design the light will pass directly along the axis of the central jet, while the ring jets are illuminated by reflection and diffusion only. This has been found in practice to give perfectly satisfactory results.

The large annular glass plate shown directly beneath the center jet, is one-quarter of an inch in thickness, and is held at the bottom of the main casting by two wrought iron rings as shown, which were previously coated with a cement of white lead and putty. The small glass disc on the main jet may be easily removed for cleaning by unscrewing the cap containing it. Owing to a slight inclination from the vertical, only a very small proportion of the water falls within the hoods, thus precluding all possibility of choking. However, for the reason to be explained later, a one-inch drain is run from each hood to a common two-inch pipe in which is placed a valve.

The motor, pump, piping and valve controllers are shown in part in the view of the operating chamber appearing on this page, while the details of the automatic valve controllers, which forms one of the most interesting features of the installation, are given in the fourth drawing. The motor is a 7½ horse-power Westinghouse multipolar machine, running at 1300 revolutions per minute, and is direct connected to a Burton centrifugal pump of the incased impeller type, with volute discharge chamber and removable side plates. It has a capacity for delivering 300 gallons per minute under a pressure of 30 pounds per square inch. With the five central nozzles open the mean height of the jets is fifty feet. No provision was made for varying the speed of the pump, as the load is within the limit of the motor capacity, irrespective of the jet area or the speed of the motor.



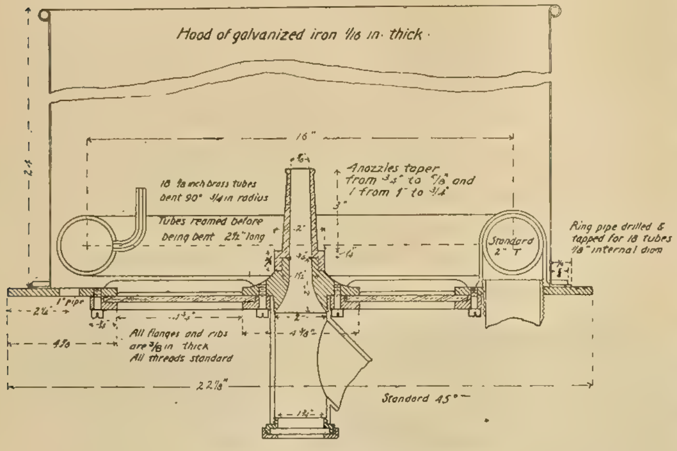
INTERIOR OF OPERATING CHAMBER.

That this condition prevails will be shown by the following electrical horse-power readings taken during actual service :

Jets in Operation.	Speed	Electrical H. P.
Center	1300	6.4
Four outer jets	1265	6.7
Rings and four	1245	7.3
All	1180	7.6

Note that the slowing down of the motor is due to the drop in the line.

Water is taken through a strainer and four-inch suction pipe placed in a small depression in the pond above the operating chamber, and the pump delivers it to the valves through a four-inch discharge. These valves are three in number, and consist of two four-inch and one three-inch gate valves. From the valves the water passes to short lengths of four-inch pipe and tees, through two and one-half-inch pipe to the ring jets, and through two-inch pipe to the central jets. All bends are made with two 45° elbows and a short nipple, thereby reducing the friction losses.


Hood of galvanized iron 1/16 in. thick
16"
24"
18 1/8 inch brass tubes bent 90° 3/4 in radius
Tubes reamed before being bent 2½" long
4 nozzles taper from 3/4" to 5/8" and 1 from 1" to 3/4"
3"
Standard 2" T
Ring pipe drilled & tapped for 18 tubes 1/8" internal diam
1" pipe
2¼"
1¾"
4⅞
4⅛"
All flanges and ribs are 3/8 in thick
All threads standard
22⅞"
Standard 45°
1¼"

CROSS SECTION OF HOODS AND NOZZLES.

The central hood contains a central nozzle three-quarters of an inch in diameter, and four outer hoods each contain a central nozzle five-eighths of an inch in diameter, in addition to which each hood has a ring of eighteen one-eighth-inch jets. With these nozzles the following combinations of jets are obtainable: 1—The 3/4-inch jet alone; 2—four 5/8-inch jets alone; 3—five ring jets alone; 4—3/4-inch center with four 5/8-inch jets; 5—3/4-inch center with five sets of ring jets; 6—revolving center nozzle with five sets of rings; and revolving center with rings and four 5/8-inch nozzles.

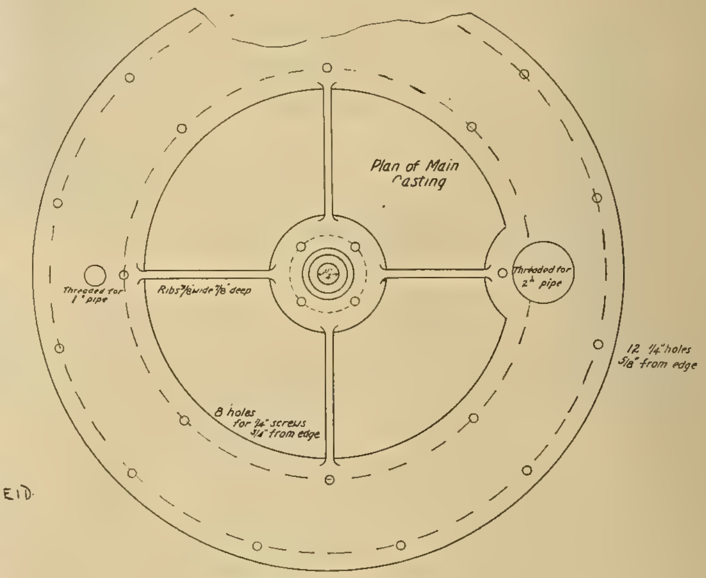
When the main valves are nearly closed and the drains fully closed by means of the two-inch valves previously mentioned, the partial opening of the main jets causes the "geyser" effect, in which the apparent seething and boiling of the water is rendered indescribably beautiful when the color screens are at play. By arranging these screens so that two or more colors are thrown up into the hood filled with water, effects are obtained which are simply exquisite. Then again, they are as cauldrons of fire or of liquid gold, stirred by an unseen hand or gyrated by the magic of some subtle art.

The fifth drawing, as stated, presents the details of the valve controllers. These are four in number and they operate respectively the three gate valves in the supply pipes and the two-inch valve in the drain pipe. They consist, essentially, of a traveling nut in combination with a magnetic clutch. The pulleys are driven in opposite directions from the motor shaft by means of a countershaft and a half-inch round leather belting, the speed of the pulleys being 240 revolutions per minute. The magnetizing coils of the clutches are wound with 400 turns of No. 24 B. & S. single, cotton covered, magnet wire, taped with two layers of bond paper, thoroughly shellacked and driven into place. Around the inner surface of each of the pulleys is cast a rim as shown in the drawing to intercept oil which would otherwise have a tendency to pass by centrifugal force directly to the clutch surfaces, thereby reducing the coefficient of adhesion; around the inner circumference of each of these rims are drilled five diagonal holes through which the accumulated oil may pass to the outer surface of the pulley, over which it may spread without, of course, impairing the action of the clutch.

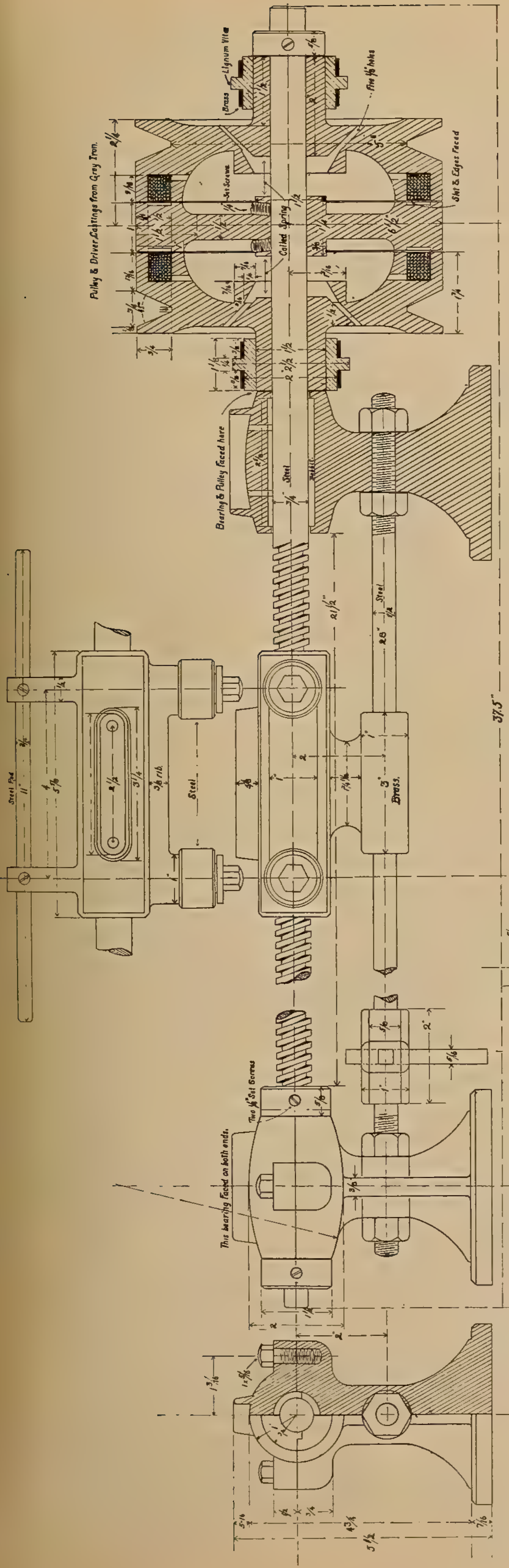
On the shaft between the driver and each pulley is placed an open coiled spiral spring of square steel wire, whose function is to promptly separate the pulley and driver upon the opening of the magnetic clutch circuit. There is also placed upon, and concentric with, the screw shaft between the traveler and each bearing, a heavy open coiled spring (not shown in the drawing) of such length that, as the traveler nears the end of its run, the spring is compressed and exerts a force of about 125 pounds throughout a range of an inch and a half, thus effectually checking further movement of the traveler due to momentum of the driver, shaft, etc. This spring acts immediately upon the opening of the limit switch, thus preventing jamming of the pulleys or valves. These switches, which are normally closed by a spring, are mounted on cast-iron frames which slide on the tie rod below the screw shaft.

The traveler carries a small steel rod shown in the upper part of the drawing, which rod engages with and opens the switches at the end of its run. It is by properly setting the switches along the tie rod that the correct travel of the unit is obtained. These clutches, when excited with a current of 3.5 amperes at 12 volts, will exert a force of 230 pounds at the traveler before slipping, although it seldom requires over 80 or 100 pounds to start the valves.

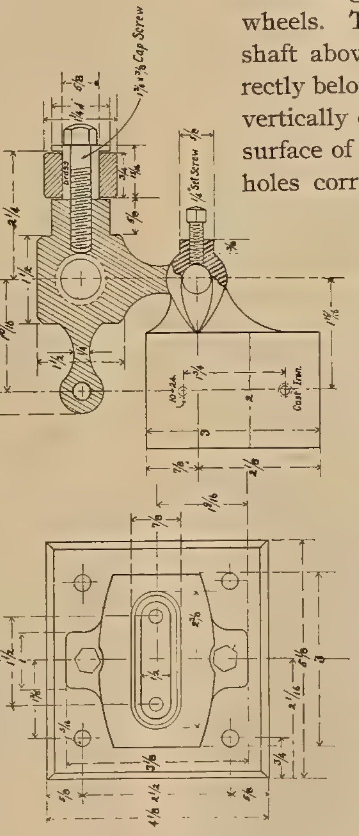
The color shifting mechanism consists of a short vertical shaft running at 20 revolutions per minute driven from the main motor. This vertical shaft has three magnetic clutches, described below, which operate independently the center or either pair of diagonal screens. Each of the latter is capable of effecting five changes of color as follows: white, blue, green, orange and red. As the fountain is often left for half an hour or more without changing the colors, the temperature acquired by the colored glass



PLAN OF HOOD CASTINGS.



AUTOMATIC VALVE CONTROLLERS.



during this time from the arcs beneath, is sufficient to crack it if it were suddenly removed and allowed to cool. To prevent such an occurrence, an alum cell was interposed between the lamp and the screen, about eight inches below the latter. This cell is merely a box 16 inches square, two inches deep, with wooden sides and a thin bottom of clear glass.

The glass plate of the alum cell is, as stated, eight inches below the color screen, and the following temperature readings, taken on horizontal thermometers placed respectively one inch above the surface of the solution and one inch below the glass bottom, will show the value of the cell when containing 1¼ inches of nearly saturated alum solution, although it may be noted in passing, that pure water is nearly as effective.

	Temp. in degrees F.			Temp. in degrees F.	
Minutes.	Above.	Below.	Minutes.	Above.	Below.
0	62	62	8	73	225
1	63	90	9	74	226
2	65	164	10	75	226
3	67	194	15	79	227
4	69	215	20	83	225
5	70	220	25	85.5	225
6	71	222	30	86.0	225
7	72	223			

Power is transmitted to the screens, which are mounted directly on the flanged union of the pipe supplying water to the ring jets, by means of chain and sprocket wheels. The three sprocket wheels on the vertical shaft above mentioned, are normally at rest; directly below each sprocket wheel is a collar sliding vertically on a feather in the shaft. In the upper surface of this collar are drilled five countersunk holes corresponding to five tapering pins in the lower surface of the sprocket wheel. When the collar is raised by means of a properly arranged system of magnets and levers, the pins engage the collar and cause the sprocket and its attendant train to revolve, thereby shifting the color screen. Immediately below each funnel aperture is a Rushmore automatic focusing arc lamp. These five focusing lamps are in series across the railway circuit, and each takes 25 amperes at 50 volts. They use cored carbons, the positive carbon being slightly larger in diameter, which was found necessary to prevent the arc from feeding past the focus of the reflector. The feeding mechanism consists of but a single shunt magnet, two gear wheels and a strong barrel spring, which is wound whenever the lamp is trimmed. The cast-iron base of each lamp rests on a wooden platform into the under side of which are driven three 1¼-inch locust pins. These pins carry inverted glass insulators, and by screwing the pins up or down, the lamp may be tilted in any direction.

The direct current for operating the motor and arc lamps reaches the switchboard from the pole line through a No. 6 lead incased cable, and it leaves the operating chamber over a No. 4 bare wire which is run through the main drain pipe and soldered to a twenty-foot length of iron pipe sunk in Lake Merritt. In addition to the three-way switches for controlling the lighting circuits of the tunnel and operating chamber, the switchboard carries two electrically actuated mercury switches with magnetic blow-outs, (in series with ordinary double-pole, single-throw switches for cutting out the entire system) for controlling the motor and arc lamp circuits respectively. The pumping motor is started by an electro-mechanical arrangement consisting of an enamel rheostat having suitably arranged contacts over which a carbon brush is caused to travel by the increasing centrifugal action of a fly-ball governor, thus cutting resistance out of the armature circuit as the motor accelerates.

The various electro-magnetic controlling devices heretofore described, are operated from a series of primary battery, from which weatherproof wires are run to two different keyboards in the residence, and a lead incased cable is run to a third keyboard concealed in a rustic house on the edge of the pond containing the electric fountain. A fourth keyboard may be seen in the general view of the operating chamber immediately over the large groove pulley. These keyboards are merely compound push buttons, and by manipulating them from either of the four stations, any desired change in the operation of the fountain from the starting of the motor to the opening or closing of the valves, or the shifting of the colors, or the arrangement of the different combination of jets, is effected.

Electro-Economics

SOME POSSIBILITIES WITH ELECTRIC PLANTS.*

BY C. O. POOLE.

IN listening to the discussions that took place at the two previous meetings of this Association in relation to electric lighting plants, I was very much impressed with the universal opinion which seemed to prevail among the members that an electric light plant was a very undesirable kind of a thing to have around. Of course, a great deal of this sentiment could be accounted for in the fact that this Association is almost entirely composed of representative gas men, and the Association was formed for the purpose of discussing gas and gas methods. Little wonder is it, then, that when some new method of lighting springs into existence, and some enterprising individual sets up a $10,000 electric lighting plant within a stone's throw of your $100,000 gas plant, that the gas man should look upon the newcomer with distrust and apprehension; and when the electric light is offered to your customers for less than gas rates, you naturally begin to lose them one by one, until you are forced to take heroic measures to protect yourself. The result is that nearly every gas man here is saddled with an electric light plant, as you call it, not by choice, but by force of circumstances. But the strangest part of it is, "Not one of them is paying," you say; they are simply kept running as a kind of necessary evil. It is the statement that your electric plants did not pay that is responsible for the title of this paper.

When our Secretary asked me to contribute a paper I accepted the invitation with the hope that I might say something which would be of service in your arduous duties of conducting an electric light plant profitably. If some idea set forth, or experience related, shall succeed in nothing else than bringing about a full discussion of the subject, I will feel amply repaid for my effort.

To begin with: You must realize and acknowledge to yourself that the electric light has come to stay, and that it will continue to grow in favor in spite of any effort that may be made to hold it back. The strides made in electricity during the past few years have been simply phenomenal, and no one can tell to what distance the march will reach in the next few years. In spite of the Welsbach burner, whose advent was to sound the deathknell of the incandescent electric light, the demand for the latter method of lighting has continued to grow, at the rate of about thirty per cent. per annum, one year over the other. Conceding, then, that the electric light has become a necessity, and that the demand for it must be satisfied, the present problem is to produce the light as cheaply as possible, so that you may reap at least a fair return on the investment. The items that go to make up the cost of production are about as follows: Fixed Charges—Interest on investment, deterioration and depreciation, taxes, insurance and administration. Station Operating Expenses — Fuel, labor, water, oil and waste, and repairs.

There are a great many electric light plants in operation that are not paying dividends. In many cases the reason for this can be traced to the fact that cheap, inefficient apparatus had been installed, both in the station and on the circuits. In many small towns on the Coast plants have been installed for the express purpose of selling them, either to the local gas company, who would buy it for self-protection, or to some ambitious individual who has no knowledge of the business and more money than good judgment. In the first case, the gas company carried the plant along and supplied its customers with electric lights when they would not have gas. The plant is looked after in a half-hearted kind of way, and if there are any burdens to be divided between the gas and electric plant the latter usually gets the worst of it. It frequently happens that attendants are not capable of properly taking care of the machinery, and the result is dissatisfaction all around. Is it any wonder that plants are a failure under such conditions?

ON STEAM EQUIPMENTS.

Steam users on the Pacific Coast are particularly unfortunate in having to pay such high prices for fuel. Coal, for which we pay $6 and $7 a ton, can be had in the eastern states for about $2. Fuel being the principal item of expense where a plant is using steam power, it behooves the manager of an electric light plant to install the most efficient apparatus to be had. The boilers should be of the modern, water tube type, capable of carrying high pressures with safety. This style of boiler will cost about $18 per horse-power, against horizontal tubular boilers at $11 per horse-power. The difference in price is about sixty per cent., but this has no terrors when you consider that a saving of about ten per cent. in fuel can be made on the higher priced boiler. If you burn five tons of $6 coal per day, there will be a saving of $1000 per year. At this rate the boiler will soon pay for itself.

The mistake is often made of putting in single cylider engines, at a price of $8.50 per horse-power, when a good compound engine can be had for $11 per horse-power, or an increase of thirty per cent.

It is an uncommonly good single cylinder engine that will do a horse-power on less than thirty-six pounds of steam, while a compound, non-condensing engine will yield a duty of twenty-six pounds, or an increase in efficiency of twenty-seven per cent. This can ill afford to be lost sight of in the selection of an engine. The prices quoted here are for boilers and engines of about 100 horse-power capacity; larger units would be proportionately cheaper. If cooling water can be had conveniently, with a condenser added to the compound engine, it will reduce the steam consumption to about twenty-one pounds, which means an increased efficiency over the last named conditions of about fifteen per cent., and a corresponding increase in the horse-power of the boiler and engine.

Connecting a condenser to an engine will generally increase the efficiency of the plant about twenty per cent., were it not for the fact that air, and sometimes circulating pumps, must be added, which require steam to run them; and, in small plants, this will amount to about five per cent. of the steam used.

---

* A paper read before the Sixth Annual Meeting of the Pacific Coast Gas Association. San Francisco, July 19, 1898.

Before leaving the subject of boilers and engines, let us consider for a moment what these different efficiencies mean. Assuming that our coal costs $6 per ton laid down in the boiler room, and that it has an evaporating power of eight pounds of feed water per pound of coal under actual conditions, then, with the single cylinder, non-condensing engine, 4.5 pounds of coal per horse-power hour would be required, while with the compound condensing engine the consumption would only be 2.6 pounds, or a saving in fuel of forty-two per cent.; which on a year's run would amount to $4,599.

SELECTING A LIGHTING GENERATOR.

Reverting again to the equipment of our plant, having installed efficient boilers and engines, we next require a generator. Too much care cannot be exercised in selecting this part of the equipment. The first thing to decide is whether or not you will want to run motors on the lighting circuits. If you do you should have a sixty-cycle machine. This periodicity is about the best where light and power are to be supplied from the same generator. If lights alone are to be supplied, a little better efficiency can be obtained in the transformers by using 125 cycles. The first cost will also be a little less; but if your lines are to be of very great length, the line losses will be a little greater with the 125-cycle than with the 60-cycle, on account of the increased inductance. If the greater part of the load is to be motors, it might be well to use a multiphase system, as this style of motor gives much better satisfaction than the single-phase machines; but my belief is that before many years the single-phase motor will reach a stage of development that will render the multiphase motor unnecessary. When this is accomplished it will simplify the distribution of light and power by alternating currents wonderfully. Taking everything into consideration, even if you see no present use for motors on your circuits, it would be well to select a 60-cycle machine, for if you ever have a demand for motor power you would be better fitted to supply it. Rotary transformers can be better operated on 60 cycles than on higher frequencies, the speeds being lower and the noise made by the machines is less objectionable.

Where lighting and power are to be supplied from the same circuits, or if lights alone are used, the electromotive force should be about 2200 volts, transforming to 110 and 220 volts, or a ratio of 20 to 1. At these pressures the line losses are quite reasonable.

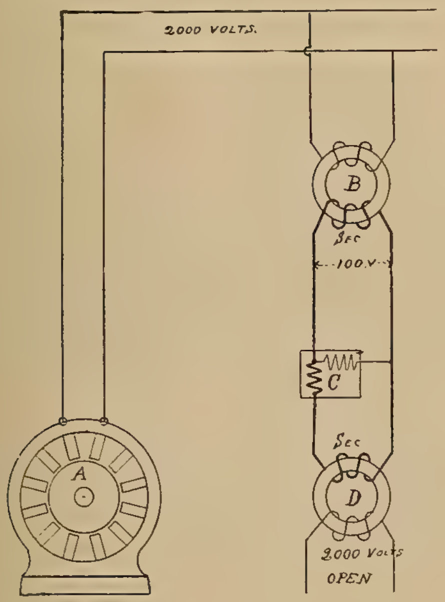


FIGURE 1.—TEST FOR CORE LOSS.

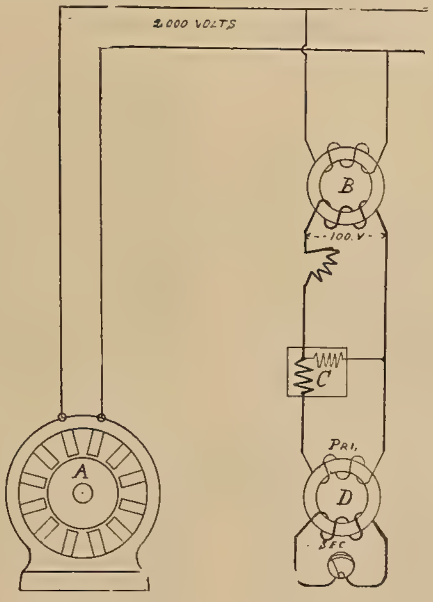


FIGURE 2.—TEST FOR COPPER LOSS.

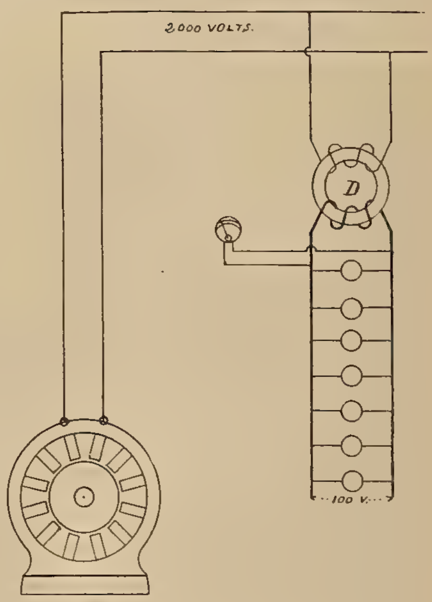


FIGURE 3.—TEST FOR REGULATION.

THE LINE.

In constructing the lines, good double or triple petticoat insulators should be used, to prevent excessive leakages and short circuits. If the circuits are to be quite long, the wires should not be separated more than about twelve inches, on account of the increased inductance that is occasioned by the separation of the wires. This is quite an important feature, especially where high frequencies are used. For instance, if a circuit of No. 4 B. & S. wires is separated twelve inches, the impedance factor at 130 periods would be 1.47, while, with the wires separated thirty-six inches, the impedance factor is increased to 1.65, or about thirteen per cent. This inductive effect seriously affects the regulation, and is frequently the cause of fluctuations in the lights of which your customers complain. It is also undesirable to use very heavy solid wires for alternating current work, as the impedance increases very rapidly with the size of wire. Authorities say that nothing larger than No. 4 B. & S. solid wire should be used. If you have occasion to use larger circuits, use several No. 4 wires or use stranded wire, which can be had for about the same price paid for solid wire.

The question of line wire insulation is something that should be governed by local conditions. Throughout cities and thickly populated towns, where there is danger of telephone, telegraph wires, etc., falling across the primary-wires, it is policy to use a good grade of rubber covered wire; but along roads, or through sparsely settled districts, weatherproof wires will serve the purpose. For secondary wiring on poles weatherproof will answer very well.

CONCERNING CONVERTER CAPACITIES.

The next thing to consider is the transformer problem, and I want to say here, if there is one thing more than another in the make-up of an alternating plant that requires special study in its selection and placing, it is the transformer. This feature alone is responsible for the absence of dividends, where a twenty-four hour service is given, more than any other one thing, and a careful study of the subject will do much toward making the stockholder happy. It is a common practice to place a transformer for every customer with a capacity sufficient to take care of his maximum load. The result is that your transformer capacity is up to the number of connected lights. In the business part of a town, and quite frequently in the suburbs, it is possible to establish secondary systems of distribution with very gratifying results. By installing a large transformer, on a pole at some convenient street corner, it is possible, with the use of the three-wire, secondary system, to distribute a distance of a quarter of a mile in any direction with a very small line loss and at a moderate cost for copper. In this way a square mile of territory can be covered from one center of distribution. By connecting a number of customers to one or more large transformers, it is not necessary to have the transformer capacity equal to the connected lights, as it never happens that everybody wants his maximum lights at the same time. I have found it good practice in large secondary systems to allow a converter capacity equal to forty per cent. of the connected lights, and in some cases I have cut it down to thirty per cent. This method not only reduces the first cost of transformers, by reducing the necessary capacity, but the price per light on large transformeas is much less than for small sizes. While the advantage of less first cost is desirable, it by no means represents the chief benefit to be derived from this system of distribution. Where a twenty-four-hour system is given, and even where the circuits run through the night only, the transformer losses represent the greater part of the kilowatts generated. It is evident, then, that anything done to decrease these perpetual losses will be a clear gain. Aside from the economical advantage of the system, a much better service can be given, the regulation being greatly improved, thus enabling more efficient lamps to be used. With good regulation it is possible to use 3.1 watt lamps, while, with the ordinary service given by alternating current systems, the customer is compelled to use inefficient lamps in order to insure a reasonable length of life. Cases have come to the writer's notice where lamps of 4.3 watts per candle power were used. The cases were investigated on complaints of high bills, which seemed quite natural under the circumstances, the lamps being forty per cent. below normal efficiency; sixteen candle power lamps were consuming seventy watts instead of fifty watts.

Coming back again to the subject of transformers, let me say experience has demonstrated that 150-light transformers are a convenient size to use for the purpose described, for the core loss of this sized transformer should not exceed 150 watts. It is common practice to displace about fifteen small transformers with one of this size, the core losses of which would aggregate 750 watts. You can easily figure what this would mean in dollars and cents. Take, for example, a plant with 1000 burning lights, and assume that 750 of these lights are supplied from 150-light transformers, and the remaining 250 lights supplied from ten-light transformers; then, for a twenty-four hour service, the core losses for a year would be 17,250 kilowatts; if it costs five cents to generate the current, the core losses per year will be $876. Assuming again that we are supplying 1000 burning lights, from old style transformers of fifteen lights capacity each, then the core losses per annum would be 37,850 kilowatts. At a cost of five cents per kilowatt, this would amount to $1,879, or a difference in favor of the former method of $1003. Deducting interest on investment for the new transformers still leaves $928. For a twelve-hour service these figures would have to be divided by two.

KEEP A STATION RECORD.

I have taken the liberty of dwelling upon the subject of transformers a little longer than would seem proper, but, realizing the importance attached to this point of the installation, I feel that the time will be well spent, if the subject of transformer losses is new to you. Every station should keep a complete record of its transformers, and before a transformer is put into service it should be tested for regulation on no load, one-quarter load, one-half load, and full load. It should be tested for core loss and copper loss. From these data the different efficiencies of the transformer can be calculated. To make the keeping of these records as convenient as possible, the writer has designed a set of cards, upon which are printed forms and columns for the different items; one side of the card is used for test data and the other for expense account. By having a record of this kind you can at any time tell just what the efficiency of the transformer is, when it was purchased, what it cost, and what the repair expense has been. Whenever it is necessary to bring a transformer in for repairs, it should always be tested before being put into service again, entering the result of the test and cost of repairs on the card or book. It is hard to realize how useful a system of records is until you have once tried it. It frequently happens that you want to bank two or more transformers, and in doing so it is essential that the secondary voltage of the transformer should be nearly the same, or a burn-out will be the result. A glance at your records will show which transformers should go together.

TESTING TRANSFORMERS

The method of testing the transformers is quite simple. The only necessary instruments are an alternating current ammeter, a voltmeter, and a wattmeter. If a direct reading wattmeter is not at hand a recording wattmeter will serve the purpose. The method of testing for iron loss is shown in Figure 1. *A* is a 2000-volt generator with the primary lines leading from it to a transformer, *B*, connected up in the regular way. *C* is a wattmeter connected in the secondary circuit of transformer *B*; *D* is the transformer to be tested. The secondaries of transformer *B* are connected to the transformer *D*, after passing through the wattmeter *C*. The primary wires of the transformer to be tested are left open. When the current is switched on for the test the wattmeter will register the watts absorbed by the core. The amount of current that would flow through the wires with which the wattmeter is connected, without the core losses is negligible; so all of the energy recorded on the wattmeter might be considered core loss. The method of testing for copper loss is shown in Figure 2. *A* is the generator, *B* the station transformer, *C* the wattmeter, and *D* the transformer to be tested. In the secondary of *B*, before the wire reaches *C*, there is interposed an adjustable resistance for the purpose of controlling the flow of current. In this case the primaries of *D* are connected to the secondaries of *B*, while the secondaries of *D* are closed through the ammeter. By adjusting the resistance referred to above, the current flowing through the secondary of *D* can be regulated to the proper amount, which should be the rated capacity in amperes of the transformer to be tested. In this case the current passing on account of the core losses, etc., is so small that it may be neglected, and the energy registered on the wattmeter may be considered the copper loss. Figure 3 shows the connections for making the regulation test. Here transformer *B* is taken out and *D* put in its place. Now, instruct the attendant at the switchboard to keep the voltage steady while the test is being made. Having provided a bank of lamps, arranged so that they may be switched on as required, then, with a voltmeter connected to the secondaries of *D*, taking a reading with no load; next switch on quarter load and take a reading; then half load with another reading. Now switch the full load and take reading. If you choose, an overload may be put on and readings taken. From the data thus obtained a regulation curve of the transformer can be plotted.

Another advantage of using large transformers with small core losses that should not be lost sight of, is the fact that the capacity of the plant is increased about five per cent. This applies to boilers, engines, generators and lines. In other words, if your plant and equipment were of just sufficient capacity to carry 1000 burning lights in the first case, you would be able, under the new conditions, to carry 1050 lights, with the same percentage of loss on generator, lines, etc.

There are places in this paper that appear disjointed and unfinished. The truth is: After outlining the necessities of a plant, I had intended to review the subject and discuss the methods of conducting the station, touching upon the cost of generation, the value of coals, the handling of boilers, engines, dynamo, etc. I had also intended to treat the subject of arc lighting to some extent, but realizing that there would be other papers of more importance than this to be read and discussed, I concluded to let the subject rest and trust to the probability of the discussion bringing up points that will be of general interest.

A late report states that the Westinghouse company has been awarded the contract for the equipment of the Third avenue surface railroad, of New York city, with the underground system.

Transmission

PARALLELING LARGE ALTERNATORS.

BY EDWARD P. BURCH.

PARALLELING large alternators often gives rise to troubles which have suggested two excellent and simple ways for obviating these difficulties. Suppose several large alternators are to be started at about the same time each day, either after cleaning or before the peak of the load comes on, or before the cars start. The method of getting them in parallel is as follows: Start them, get them at approximately the same speed, and connect the unexcited alternators in parallel by means of the usual switches. After this, close the field switches of the alternators and then excite all the alternators simultaneously by closing the exciter switch. The alternators will buck for a minute and then settle down. If the governors are throttled the bucking will be easier, since the hunting does not tend to pull them apart. There are no dangers, no broken switches, and much time is saved. The plan is especially useful in water-power plants which are operating electric railway systems.

Again, suppose four units are already in parallel, and that after a time a fifth is to be thrown in parallel. Instead of watching the flickering of the phase lamps the following plan has been found convenient and safe with ironclad generators having a high or moderate armature reaction: Get the fifth machine up to speed and then throw in the paralleling switch, without exciting the machine.

Its armature instantly takes a lagging current, which acts like a transformer with an open circuited secondary. The field current may then be thrown on without any delay and the lagging current is eliminated. A high voltage may be developed in the field coils, but since they are closed on themselves through the kicking rheostat this is avoided. There is a mechanical strain on the armature coils, but experience shows that they are ordinarily put up solidly. In this plan the armature lagging current comes from four machines and does not produce more than a wink in the lights. Moreover, the lagging current is generally not as heavy as in the case of paralleling by the use of phase lamps.

CALCULATING THREE-PHASE CIRCUITS.

THE following is a simple and satisfactory rule for the calculation of three-phase, three-wire circuits: The ratio of the amounts of copper used for equal power, drop and voltage, is 100 for the single-phase and 75 for the three-phase system. The single-phase system, as is well known, is calculated by ordinary direct current rules and uses two wires. The three-phase system uses three wires. It then follows, that, if we calculate the proper size of wire by ordinary direct current rules, and then divide the circular milage of that wire by two, we shall have the proper size of wire for a three-phase circuit, because seventy-five per cent. of the volume of two wires of a given size is equal to the volume of three wires of half that size, lengths being equal. —*American Electrician.*

Telegraphy

JAPAN AS AN ELECTRICAL CENTER.

AN idea of the progress that has been made in the development of the electrical industry in Japan is given in an interesting lecture delivered by Prof. I. Fujioka, of Tokio, before the New York Electrical Society recently, in which it was stated that the telegraph system of Japan, which is controlled by the government, comprises 12,000 miles of land lines and 388 miles of submarine cables in addition to the cable to Formosa, which is 800 miles long. There are 1122 telegraph offices, which handle exceeding 22,250,000 messages per year, as well as 150,000 cablegrams. The telephone system is also owned and operated by the government. The first exchange was opened in 1890 and in 1896 there were 540 miles of lines and 3232 subscribers, but the telephone business, which is now growing very rapidly, has, until very recently, been very seriously handicapped by the inability of the government to secure instruments sufficient to meet the demand. Nearly all the larger towns are now supplied with both arc and incandescent electric lighting systems, and in Tokio alone there are more than 50,000 incandescents. Several water power transmission plants are now under construction, some of them possessing specially interesting features.

Personal

MR. W. W. BRIGGS, the worthy electrical engineer for the Pacific Coast office of the Fort Wayne Electric Corporation, was married on September 28th in Santa Ana, Cal., to Miss Charlotte May Clough, and to the many congratulations that the accomplished bride and genial groom are receiving, THE JOURNAL OF ELECTRICITY desires to extend its best well-wishes.

MR. A. I. NEISSER, general western representative of the Central Electric Company, of Chicago, has returned to Los Angeles after spending five weeks in and about San Francisco, and after concluding arrangements for a San Francisco office for that concern, whence will be handled its business for northern California, Oregon and Washington.

Obituary

DR. JOHN HOPKINSON, F. R. S.

INEXPRESSIBLY sad was the death of Dr. John Hopkinson, F. R. S., who, with his son and two daughters, perished on August 27th, while making the ascent of the Petite Deut de Veisivi, Switzerland. Dr. Hopkinson's favorite recreation was in climbing the Alps, and he was conceded to be a keen and experienced mountaineer, as were also his grown sons and daughters. The Petite Deut de Veisivi is not considered to be an ascent of great importance, but at certain points the footing is difficult, and it is surmised that one of the party must have slipped, causing all four to fall. Their bodies, roped together, and fearfully mangled, were found in a moraine at the foot of the cliff from which they had fallen, over six hundred feet above.

Dr. Hopkinson was one of the foremost of the world's electricians, and his name has long since been familiar to American engineers as the man who, co-temporarily with Edison, invented the three-wire system, and as the man who, in bringing out the Edison-Hopkinson dynamo, almost doubled the efficiency of Edison's original incandescent lighting dynamo. The joint contributions of Dr. John Hopkinson and his brother, Dr. Edward Hopkinson, to the proceedings of the Royal Society, on dynamo-electric machinery, have exercised enormous influence on the design of modern generators, and as early as 1883 he announced his conviction that alternators could be successfully run in parallel. In 1879 and 1880, he read papers before the British Institution of Mechanical Engineers introducing the now universally-used method of graphically analyzing the behavior of dynamos by means of characteristic curves. From 1884 up to the present time his contributions of papers to the British Institution of Electrical Engineers have each been of almost epoch-making importance. Aside from his electrical labors, he won great distinction in other fields of scientific research and invention; to him is due, for instance, the system of group-flashing lights for lighthouses now adopted by all maritime nations. The greatest honors that the electrical engineers of England can extend have been repeatedly bestowed upon Dr. Hopkinson, for whose loss the electrical world laments, and to whose surviving widow and children the hearts of American scientists go out in sympathy and bereavement.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of
Electricity and Transmission of Power.

Official Organ of the Pacific Coast Electric Transmission Association.

Subscription invariably payable in advance. Terms—Domestic, One Dollar per Year; Foreign, Two Dollars per Year. The trade supplied by the San Francisco News Company. Advertising rates furnished on application.

GEO. P. LOW, : : : Editor and Proprietor

PUBLICATION OFFICE:
320 CALIFORNIA STREET,
ROOM 14.

Address all communications to
Editorial rooms, 427 TENTH AVE.
Telephone, "Steiner 623."

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME VI OCTOBER, 1898 NUMBER 4

EDITORIAL.

THE BURIAL OF A BUGABOO.

A timely contribution to literature on the hygroscopic properties of glass insulators is that of Lieut. W. Stuart-Smith in THE JOURNAL OF ELECTRICITY for September, in discussing "Moisture on High Tension Insulators." In this article, which, though brief, is one of the most important that has been brought before electric transmission interests, the author recalls the early teachings that "like" electricities repel, and that, on any conducting body, a static charge will only be found on the surface, as far from the center as possible; *i. e.:* it will divide itself over the greatest possible surface, thereby causing the tension to become a minimum. When an insulator becomes wet from any source, the presence of the static charge from the line, and the tendency to divide itself over the greatest possible surface, gives rise to a repulsive force between the neighboring water molecules, which, in turn, results in the molecules flying off into space.

Thus, in theory, is an accounting given for the fact that any moisture appearing on glass or porcelain insulators on high tension lines, is dissipated so effectually that the hardest rainstorms exert no appreciable influence on the insulation resistance of long lines, even when the rains are long continued. In Lieut. Stuart-Smith's theory is found, moreover, a plausible reason why it is very difficult and sometimes impossible, to start the Provo-Mercur 40,000-volt transmission during rainy weather, although, when once started, the occurrence of the heaviest rains does not affect the operation of the lines. Other similar experiences will be understood on comprehending the application of the laws of static electricity so concisely stated in the article referred to.

How often it has been the case in the history of electricity that the apparent bugbears of the science have, in time, been found to be its real benefactors. The present theme is a case in point: Static electricity has been a source of never-ending trouble from the earliest days of dynamo electric machinery when a spark from the rapidly moving belt would puncture the insulation, opening up a path for the armature current to follow, with a burn-out in consequence. It has made paper making and the working of fabrics almost doubly difficult processes; it has broken tens of thousands of incandescent lamps, and has caused fires and explosions. In transmission practice it has opened the way for the line potential to break down the insulators; it has burned off pins and caused transformer burn-outs and lightning arrester "shorts" galore; and it has, in brief, apparently earned every condemnation that the exasperated engineer can heap upon it; but now, as if repentant and anxious to redeem itself with modesty, it has stepped into a breach which human ingenuity seemingly could not fill, and has robbed the hygroscopic properties of glass insulators of all the terrors which years of harping has instilled into the heads of the electrical transmission fraternity.

It seems now as though insulators are able to withstand moisture even when precipitated from drenching fogs—thanks to their own worth and to the static charge of the line—but to do this effectually at all times, they must be kept clean. In all probability the next problem that will have to be overcome in high tension work is, therefore, the devising of means for cleaning insulators of the dust that, in some cases, cakes on the windward sides like so much clay thrown against them. In the early days of the telegraph no thought was given to preserving cleanliness of insulator surfaces, but now the insulators on long telegraph lines are cleaned periodically to prevent leakage from line to line and to earth, while in some instances—between Oakland and Port Costa, for instance—the conditions are so bad that it is found necessary to put up new insulators and take the old ones to the storerooms to be cleaned as often as three or four times a year. If it is necessary to clean insulators to avoid leakage in telegraph practice, it is not unthinkable that in the same procedure may be found a remedy for some of the difficulties that will probably attend transmission at extremely high voltages.

Given clean insulator surfaces and the beneficent influences of static electricity, and in the light of the most recent opinions, there is little or nothing remaining to controvert the belief that all the talk that has been poured into our ears in hum-drum profuseness anent the hygroscopic properties of glass insulators, has been based on but the merest moonshine.

HOW SHALL WE DRIVE EXCITERS?

A mooted point in the design of water power plants is found in the varying opinions existing as to whether exciters should be driven by belting from the main generator shafts or independently by means of individual water wheels. From the exciter flows the life blood of the transmission system, and it must never fail to do its duty or the entire plant will become inoperative. It is of paramount importance then, that the exciter should be as near being absolutely infallible as it is possible for human ingenuity to make it.

Each system has its advocates, though neither is without an inherent evil.

Without particularizing deeply, it may be stated that the advantages accruing from the independent driving of the exciter, rest in its ability to maintain the generator fields to any degree of excitation, regardless of the load or any speed fluctuation that may occur in the generator. On the other hand, many believe independent driving to be less reliable because, when operating under high heads, the jet driving the exciter wheel is of very small diameter, thereby incurring the liability of its becoming choked by bits of leaves or twigs or small pebbles that may come down the pipe line. This latter is, in reality, the only serious objection that has been raised against the independent driving of exciters.

The merits and demerits of driving from the generator shaft are not so easily presented, but about all that can be said in favor of this mode is that as the main water wheel is not liable to clogging from debris coming down the pipe line, the exciter driven from it is more reliable than when driven from a small separate wheel. The efficiency of the two methods are perhaps about equal, for while the efficiency of the smaller wheel is lower than that of the large one, the losses in belting to the exciter will make up the difference. As to the disadvantages of belt driving from the generator shaft, they are not many, but they are very serious. Obviously, the speed of the exciter varies directly with the speed of the generator, and as the electromotive force of the exciter, and consequently, the field of the generator, is thus directly dependent upon the speed of the generator armature, any increase in load that slows down the water wheel will make this decrease in speed doubly apparent because the generator fields will be weakened proportionately. To assume an aggravated, though not unprecedented case: Should a load sufficiently heavy to reduce the speed of the generator by fifty per cent. be suddenly thrown on, the electromotive force of the generator would be reduced thereby about fifty per cent., provided the fields remained constant. But as the exciter is driven from the generator shaft, its speed has also been halved, its output has been decreased one-half, and the generator fields are, in consequence, but fifty per cent. of the normal. In running under one-half speed and at one-half excitation, the generator will be able to deliver but about one-fourth of its rated output. Worse than this, the increased armature currents due to the slower speed will react on the fields, still further reducing them to an extent that can not be predetermined. It is reasonable, therefore, to attribute at least fifty per cent. of this falling off in capacity to the generator-driven exciter. Again, exciters driven from generator shafts are practically non-interchangeable, and they are, furthermore, subject to all the ills to which belting is liable.

And all this is tolerated for what? Simply to save the slightly increased cost of independent water wheels and to avoid the possibility that the small jets of the exciter wheels may become choked from debris in the water supply.

The problem resolves itself into a choice between two evils. First, the liability of the exciter wheel nozzle to become choked, which is preventible; and, second, the liability of the generator to "lay down" on every occassion of sudden heavy load, which is not preventible without independent excitation. Of these evils, choose the least.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

OVER-CONSERVATISM IN ENGLAND.

Americans who have marvelled at the comparative slowness of the development of electrical enterprises in England, despite the high attainments of her scientists and the thoroughness of her engineers, neither of whom are excelled by the engineers of any other country, will find a solution to their perplexities given in a paper read by Mr. Alexander Siemens before the last meeting of the British Association for the Advancement of Science. In this Mr. Siemens says:

> It is characteristic for England that transmission of power over a large district had to be taken from foreign practice. However enterprising and progressive the individual Englishman is, when a novelty can be introduced only by the co-operation of a municipality, of a county council, or, worse of all, of Parliament, everybody appears to consider it a patriotic duty to throw obstacles in its way, and in most cases it is quite impossible to find out who profits by such action. After a while the public discovers that the introduction of the novelty would be a great convenience, and an agitation is set on foot to remove the obstacles which were, in many cases, introduced only to satisfy prejudices. Let us hope that a similar fate may not befall the transmission of power by electricity.

* * *

STATISTICS CONCERNING ELECTRIC RAILWAYS.

Some interesting statistics are given by the *Street Railway Review* in an article on "The Electric Railway: Its Greatness and Possibilities." Before the days of street cars, the residence district of a city, measured by a circle described by the distance a man could walk in thirty minutes used as a radius, was but 9.6 square miles; horse cars increased this radius from one and three-quarter miles to three miles and the residence area to 28.3 square miles, but the advent of the trolley still further expanded the area to 113 square miles, or at a radius of six miles from the center. More than half of the population of the states having the greatest street railway mileage live in cities. The sale of the street railways of the United States would easily realize sufficient money to pay the national debt.

Nearly 2700 million paying passengers are carried by the street railways annually, and this number would be increased by fifty per cent. if the transferred passengers were counted. The first figure alone is almost five times the number of passengers carried annually on the 182,000 miles of steam roads in this country. The average rate of fare on steam roads is 2.04 cents per mile; on street railroads it is but a fraction of a cent—just how much can not be closely estimated. There are 16,000 miles of street railways in the United States, to build which required 33,000,000 ties and 3,500,000 tons of steel rails which, if stretched end to end, would encircle the earth at the equator and leave enough remaining for an axis extending from the north pole to the south pole. As to power: There are in this country 525,000 horse-power in boilers, engines and generators, the boilers consuming two and one-third millions tons of coal per annum. The actual employees number 200,000 men.

And what to the safety of the millions who entrust themselves to the electric car? The average electric car travels 120 miles per day; each one of its wheels makes 84,500 revolutions, and in the course of a year passes over eight million rail joints; yet with all this wear and constant opportunity for accident from breakage, a passenger is as safe on a trolley car as he is in his own home. Only one in 23,000,000 passengers is killed, and only one in 800,000 is injured in any way, and if a man were to spend his time on the street cars waiting for a chance to present a damage claim against the company, he would have to travel one hour a day for thirty-one years and spend $1130 in car fare before he would be hurt. Before his time for being killed would come, he would be a patriarch of five and a half centuries, having been continually on the cars day and night.

Where the expansion in electric railway work will cease no one can tell, for long lines are now in operation which were deemed impractical five years ago, and even greater and broader undertakings are being planned. The advent of the first electric railroad in nearly all large cities is still within the memory of those who are yet at school, and when we remember the almost incredible rapidity with which its development has been marked and then reflect on the limitless possibilities before it, we will not find it hard to believe that of all the applications of electricity, the street railway industry is fully as promising as any other.

SYNCHRONOUS VS. INDUCTION MOTORS.*

THE induction motor is undoubtedly a more difficult and expensive machine to build for satisfactory duty than is the synchronous motor with fields excited by direct current. The field of the induction machine is necessarily excited by wattless alternating currents lagging behind the impressed electromotive force waves, and the reduction of these lagging currents to a minimum is essential to good voltage regulation. This requires that the self-induction of both the primary and secondary of the motor be kept as low as possible, and that the air gap be also reduced. The low self-induction means a multiplication of the slots, which must be more numerous, and consequently narrower, than is necessary in synchronous machines of the same size, speed and frequency. This makes induction motors more difficult to wind and to insulate and absolutely prohibits their connection direct to high voltage circuits, since the insulation required for many thousand volts would leave in these narrow slots no room for copper. Induction motors, therefore, must be supplied from high voltage transmission lines through step-down transformers. This requirement does not apply to synchronous motors, which are constructed now even in moderate sizes to take 10,000 volts direct. Extreme reduction of the air gap is also, of course, an added expense in the construction of the machine, as the parts must be accurately true and extremely rigid to run with a gap of one-sixteenth of an inch or less, as is now customary with rotors several feet in diameter.

The necessity of keeping down the magnetizing current in the induction motor increases its cost in another way, since it requires that a high magnetic induction shall not be used. The induction commonly used in synchronous motors is 100 per cent or more greater than that used in good induction motors, and the output of the same amount of material is correspondingly increased. This advantage is partially, or often, wholly compensated by the fact that induction motors are worked usually at peripheral velocities higher than those used with any other type of electrical machines, running up often to 6000 or 7000 feet per minute, a practice perhaps justified by the simple, substantial and symmetrical character of the rotor when this is a "squirrel cage" secondary, although a synchronous motor with internal revolving fields is apparently capable mechanically of fully as high a speed. The main object of the high peripheral speed of the induction motor is, of course to broaden the teeth and slots, with a fixed number of slots per pole and per phase. The comparatively high induction of the synchronous motor is permissible at all frequencies, owing to its better ventilating qualities, especially with unitooth structures, as compared with that of the induction motor, the ventilating ducts of which are seriously obstructed by the finely divided winding.

In the matter of starting, one type of the induction motor has a great advantage. With a wound secondary and an adjustable resistance in this circuit, an induction motor can be started under any load with the same current that that torque would require at full speed. With short circuited or "squirrel cage" secondaries, a construction highly desirable owing to its simplicity and durability, induction motors (properly designed with low magnetic leakage) can be started light without excessive currents, and if thrown directly across the mains at standstill will develop a torque two or more times that of full rated load, which is sufficient to overcome the standstill resistance of any style of commercial load; but, unfortunately, they take to do this four or five times their rated full load current, a considerable part of which is lagging. By means of voltage reducing transformers, the current drawn from the line and the torque can be reduced, the voltage reduction being limited by the torque required to start, since the torque is proportional to the square of the voltage. Synchronous motors, when constructed for self-starting on the induction principle — the field magnets being arranged to give a more or less effective closed circuit secondary — have starting properties very similar to those of the induction motor with short-circuited secondary just mentioned, machines of the revolving field type having been constructed which could start, if thrown across the lines at standstill, against their rated-load torque with a current consumption about two and a half times that with the same load at synchronous speed.

The synchronous motor is, of course, out of the question for cranes, elevators and similar work, where a good torque per ampere is required over a great range of speeds. The induction motor with a variable resistance in the secondary behaves with such loads just as does a direct current, shunt wound motor controlled with a resistance in the armature circuit. The most satisfactory machine for such loads from the standpoint of flexibility, is the induction motor with a permanently high secondary resistance, the control being effected by a variation of the voltage, the action of such a motor being closely similar to that of a direct current series motor on constant-potential circuits with rheostatic control (the speed varying somewhat in the inverse ratio with the load), the main differences being that the induction motor will not run away on no load, as will the direct current machine, and that its efficiency is low at any and all speeds, owing to the high secondary resistance.

In the matter of overload capacity each type breaks down and stops when the load exceeds a certain limit. With induction motors this limit used to be from 50 to 100 per cent. higher than the rated load of the machine, but with modern types of low self-induction such motors will carry three, four, or even more times their rated load without stopping. A good synchronous motor will carry so many times its rated load that it is impossible as a rule to test its capacity in this respect, the excessive heating destroying the motor before its breakdown limit can be determined. The synchronous motor has slightly better speed regulation than the other, as it maintains the same speed in cycles per second as the generator at all loads, while the induction motor with low resistance secondary, has a slight slip proportional to the load and amounting to about five per cent. in large machines at full load.

In many cases the greatest advantages of the synchronous motor is its ability to work without lagging or even cause leading currents in the apparatus and lines supplying it. The induction motor is the simpler of the two, requires less skilled attention and no exciter, but takes lagging currents which increase the drop in the generators, the lines and the transformers supplying it by a percentage far greater than the actual increase of the current consumption, owing to the reactive effects. The ordinary method of expressing the relative magnitude of wattless and energy currents—namely, by the power factor percentage—is, by the way, a snare and a delusion. A power factor of 90 or 94 per cent., values often obtained with large induction motors at full load, gives the impression that the wattless currents are only from six to ten per cent. of the total, whereas, on account of the vectorial relation, the wattless currents are in the one case one-third and in the other case one-half as great as the energy currents, giving in combination with the self-induction of generators, lines and transformers, corresponding reactive voltage drops. Synchronous excited machines, on the other hand, can, by powerful field excitation, be made to take wattless currents leading the impressed electromotive force, which not only do not increase the line drop, but act on the self-induction of the circuit to build up the voltage, and may, therefore, be made to neutralize the ohmic drop and even more than counterbalance it, making the voltage delivered at the receiving end greater than that generated. A synchronous machine, however, requires an exciter or some source of direct current to supply its field winding, and to obtain good regulation of the line-drop by its means, requires intelligent attendance. Where a large number of small motors is distributed over one circuit, the induction motor is undoubtedly the preferable type, owing to the simplicity of its construction and operation; but where the transmission of power is to one or a small number of large motors, and especially where the distance of transmission is great, the synchronous type is preferable, owing to its lower first cost, lower line-drop and low cost of attendance per horse-power output. Where power is transmitted to many small motors and also over the same lines to one or a few comparatively large machines, the ideal solution is to make the small machines of the induction type and the large machine or machines synchronous, the latter being made to take sufficient leading currents to balance out the lagging currents of the former.—*Electrical World.*

---

* Several points suggested in this article will be discussed in the next issue of THE JOURNAL OF ELECTRICITY.—Ed.

Physics

ELECTROLYSIS OF WATER.

THE chief difficulty in the preparation of hydrogen and oxygen by the electrolysis of water lies in the complete separation of the gases with due regard to economy. Attempts in this direction have hitherto only been made with the aid of non-permeable diaphragms between the electrodes; but owing to the great resistance thus offered to the current, and to practical difficulties, such methods have no commercial value. The use of metallic diaphragms has been considered impossible, it being supposed that they must necessarily take part in the electrolysis, hydrogen being evolved at the face opposite the annode, and oxygen at that opposite the cathode. This is indeed the case if the electrodes are completely separated by the diaphragm, the use of which merely converts the one cell into two, but if the electrodes are not completely separated, and if sufficient space is provided below the diaphragm to allow of the passage of the liquid from one electrode to another, the element behaves as a simple cell. This is the principle of the process used by P. Garuti, as described by him in *Electricita*, Milan, a more detailed description of which is reserved. A plant of thirty-two cells, however, yielding daily thirty cubic metres of oxygen, and sixty metres of hydrogen, has been working for six months at Tivoli, and the gases are sufficiently pure for industrial purposes, the oxygen containing about 1.5 per cent. of hydrogen, and the hydrogen containing only a trace of oxygen.—*Science Abstracts.*

SUBSTITUTES FOR COPPER AS A CONDUCTOR.

The relative costs of copper, aluminum, and iron, when used as electrical conductors, is discussed by John B. C. Kershaw, F. I. C., in a current number of *The Electrical Review*, London, (Vol. XLIII, page 331,) the cost ratio being calculated for wires of equal length and equal resistance. The conclusions reached are given in the following table, wherein the results are expressed as cost ratios to iron, which is taken as 100:

Metal.	Purity and Price.	Relative Costs.
Aluminum.....	99 per cent. at present market prices.............	375
Copper	Electrolytic, at present market prices............	278
Aluminum.....	100 per cent. at 29 cents per pound................	275
Iron.	At present market prices. plus 38 per cent for rolling costs..........	100

Regarding the above, V. Zingler holds, in a communication to the London *Electrical Review*, that while no claim is made for insulated aluminum wires for bare aerial transmission purposes, aluminum has the following advantages;

1—For equal conductivity, aluminum is half the weight of copper.

2—For equal conductivity, aluminum has about the same breaking strain as copper, if not more.

3—Therefore, for equal conductivity, the spans may be about double those with copper wire.

4—For equal conductivity with aluminum at 29 cents per pound, the cost is nearly the same as copper.

MEASURING THREE-PHASE CIRCUITS.

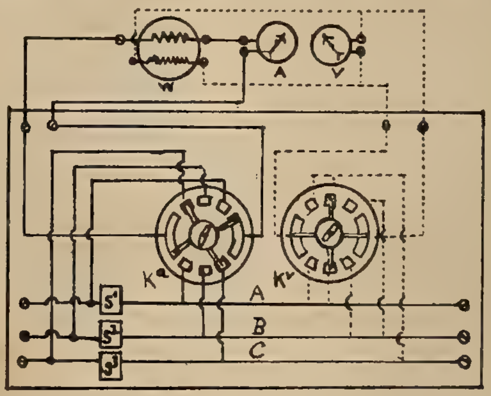
THE following formula is given by M. Aliament, in *Electricien*, (Vol. XV., page 243) for the measurement of power in a tri-phase circuit by two wattmeter readings, viz.:

$$P = p_{13} c_3 + p_{12} c_2,$$

where c_2, c_3 are respectively the currents in the second and third wires, and p_{13}, p_{12} are the differences of potential between the first and third, and the first and second wires respectively.

Aliament then describes the connections for using a single wattmeter so that both these readings may be taken in quick succession. It is shown diagramatically in the accompanying figure in which K^a and K^v are commutators by means of which the thick and thin coils of the wattmeter are placed first in one circuit and then in the other. The line is carried through the terminals A, B and C, and the switches S^1, S^2 and S^3 serve to short circuit the instrument, thus preserving the continuity of the line wires.

To take readings, the switches S^2 and S^3 are closed, and the commutator K^a is so placed that the thick wire of the wattmeter is inserted in the line wire C, while the commutator K^v is arranged so as to connect the thin wire across the terminals A and C. Opening switch S^3 and closing S^1 and S^2, the first reading is taken. Similarly, by closing switches S^1 and S^3, opening S^2, and changing the commutators K^a and K^v, the second reading is taken.—*Science Abstracts.*



Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

IMPROVED BRUSH ARC LAMPS.

PERHAPS the most essential qualifications of a satisfactory arc lamp are durability of the wearing parts and facility of renewals. High economy of operation will seldom balance a heavy repair bill or compensate for time lost in removing lamps to the shops for renewals; and in redesigning the well known Brush single and double carbon lamps, the necessity of producing durable lamps with easily renewable parts has been the object of special consideration. In the latest type, now put out by the General Electric Company, every improvement has been incorporated which long experience has shown to be advisable.

The differential Brush arc lamp is especially valuable where a large number of lamps are run from one generator. The differential winding consists of a coil of coarse wire in series with the arc, and a fine wire coil connected around the arc. Current in the coarse wire tends to separate the carbons, while in the fine wires it operates to bring them together, and, the opposite forces exerted by the shunt and series windings being automatically balanced when the carbons are burning normally, if the series current is reduced the voltage at the lamp correspondingly diminishes. With differential lamps, generators can, therefore, be heavily overloaded. The improved Brush lamp is adjusted at the factory and, as the mechanism is not dependent upon springs for any of its movements, this adjustment cannot change. Hence the lamp runs as economically after several years of service as when first installed. It regulates so closely that the voltmeter on a circuit of lamps shows no appreciable variation.

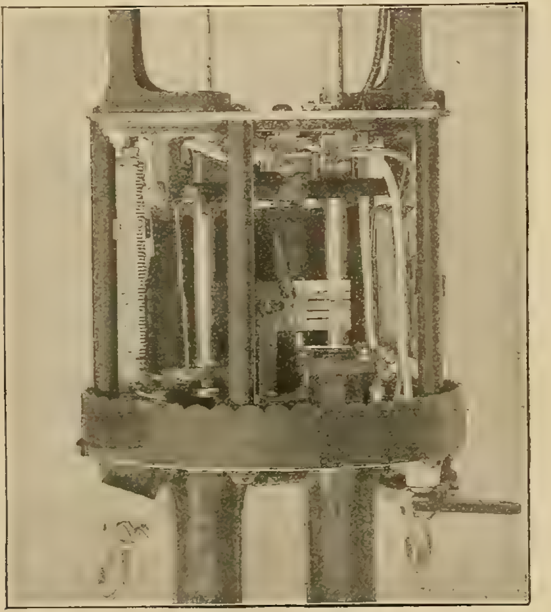


FIGURE 1.—BRUSH ARC LAMP. MECHANISM WITH CASING REMOVED.

These lamps do not require hoods when hung outside, as all parts are thoroughly protected from the weather. The chimney and its base are cast in one piece, and, wherever a screw enters the lamp from above, its head rests on a boss which prevents the entrance of rain or melted snow. The outside terminals of the lamp are made with petticoats as a further protection against the entrance of water.

All parts are made by special machinery and are interchangeable. There are no springs to adjust or replace. The various contact surfaces are ample, and the insulation is so distributed that the danger of short circuits is eliminated. The use of one large insulating strip diminishes the number of insulation pieces required to secure the lower frame in position. All brass parts, except the carbon rods, are finished in nickel plate, adding to their durability as well as to the appearance of the lamp.

The mechanism frame has been so modified that the armature lever is now supported by a base separate from the frame and mounted on a plate which insulates it entirely from the frame and zinc bottom of the lamp box. The armature lever has been changed slightly on account of changes in other parts, and also to support the balance wire in the double lamps that the second carbon feeds at practically the same voltage as the first carbon. This improvement makes a marked saving during the entire second half of the night's run, often amounting to from thirty to fifty watts.

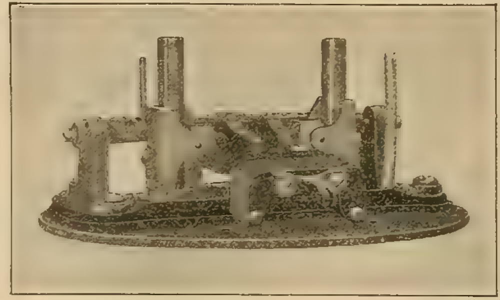


FIGURE 2.—SUPPORT FOR ARMATURE LEVER.

Realizing the advantage of using a lamp on circuits of either 6.6 or 9.6 amperes, the magnets of this new lamp have been so designed that when changing from one circuit to the other it is only necessary to exchange the adjusting coil for one suited to the new rating. The adjuster formerly sent out may be used for 1200 candle-power (6.6 amperes), but should be changed to one of coarser wire when used for 2000 candle-power (9.6 amperes). The new magnets are interchangeable in pairs with those of the old style lamp, but new magnets for old 2000 candle-power lamps must be always used with the new adjuster for 2000 candle-power. The new adjusting coil is furnished with a screw clip which compensates for about one ampere either more or less. When changing or renewing this coil it is only necessary to loosen two screws. The magnets may be removed by simply taking out four screws and unhooking the small brass connecting springs. The connection springs furnish a most convenient method of connecting the magnets into circuit, and are of such sizes that the current they carry cannot heat them enough to change their tension.

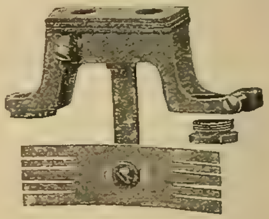


FIGURE 3.—DOUBLE CARBON BRUSH AND INSIDE TERMINAL.

Successful operation requires at all times a perfect contact between the rod and the inside terminal. In this lamp it is necessarily a sliding contact, and the brush keeps the surface bright and clean. The new brush is one inch wide, punched out of phosphor bronze, and so slotted as to present five narrow fingers crosswise to the rod. The same punching is used on both single and double lamps, the double lamp requiring two strips, and the single lamp one strip bent double. When worn out the contact brush may be quickly replaced without disturbing any other parts of the lamp. The improved contact is interchangeable with the old if the new contact support bracket is also used.

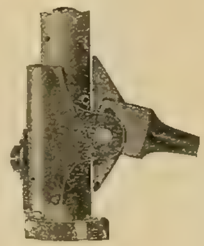


FIGURE 4.—CLUTCH WITH ROD RELEASED.

No part of an arc lamp is more effected by wear than the carbon rod. Each day the exposed portion of the rod is rubbed, and in time, its diameter so reduced that the clutch opens more quickly than when the rod is full size. The new form of clutch makes the feeding of the lamp independent of changes in the diameter of the rod. The wear caused by scouring is on the lower half—the part that rests in the bushings when new carbons are in the holders and the best alignment is necessary. To overcome trouble due to excessive wear, a reversible rod is introduced which may be quickly removed, turned end for end, and put back into the lamp, while the lamp is hanging in position. The reversible rod lasts twice as long as the old rod. It also prolongs the life of the contact brushes, the guide bushings and the clutches, a rough or pitted arc causing arcing and increased friction. The rod caps are held in place while the rod is unscrewed, and are long enough to remain in position on the upper bushing when the rod has been removed.

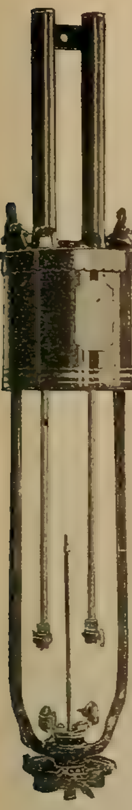


FIG. 6—DOUBLE CARBON BRUSH ARC LAMP.

The two things necessary in a satisfactory carbon rod clutch — absolute uniformity of grip irrespective of the condition of the rod, and a means of accurate adjustment for wear of the rod or clutch — are found in the improved clutch. The surfaces bearing on the rod are so long (1¼ in.) that the grip is not affected by roughness, dirt, or even dents in the rod. To adjust the clutch the position of the trip is changed by loosening one screw only.

The shoe is of peculiar construction, being pivoted above its center to a lever which, itself, is so pivoted to the clutch body as to give a motion to the shoe perpendicular to the rod when the lever moves vertically. In action this clutch is positive —releasing the rod at a given point and instantly gripping it again when the lever is raised. The rod is always either firmly clutched or entirely free to fall. The clutch comprises but four parts beside the screw and rivets, and the same clutch is used on both the single and double lamps. The bushings for guiding the carbon rods must be replaced occasionally, a worn out bushing being often a source of trouble. The main inside terminal of the lamps have been so modified that but a few minutes' work is required to replace a worn bushing. The carbon rod is removed from its cap, the worn bushing unscrewed, the new one inserted, and the rod replaced. The new bushings cannot be used in the old lamps without a new inside terminal which may be substituted for the old terminal and admit also the use of the new upper bushings.

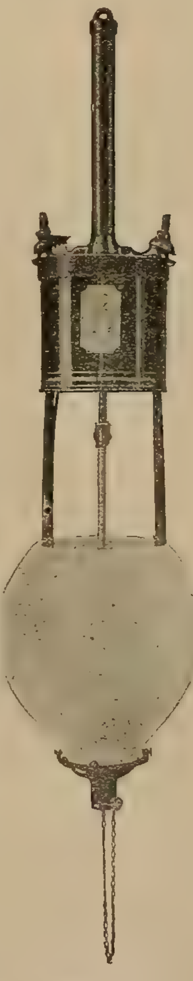


FIG. 7.—SINGLE CARBON BRUSH ARC LAMP.

The carbon holders have a V grip on the carbon. The upper holder is made in two sizes, taking $\frac{7}{16}$ or ½-inch carbons, and $\frac{9}{16}$ or ⅝-inch carbons respectively. It may be supplied with a flange to prevent injury to the rod in case of a flaming carbon. The lower carbon holder takes any size of carbon from $\frac{7}{16}$ to ⅝-inch inclusive. Its position is adjustable. To enable them to resist corrosion the holders are nickel plated.

The starting resistance is wound on a separate frame, which may be quickly removed, as only one screw with a metal clamp secures it to the side frame of the lamp mechanism. The cut-out is operated by the mechanical movement of the armature. When the current is too weak to energize the magnets, the armature falls by force of gravity, throwing the cut-out into circuit. Its contact surfaces are broad, and, as they are vertical, dust cannot collect on them to prevent good connection.

In cases of accident to the main circuit of the lamp, such as breaking the carbons, the whole current of the lamp would tend to flow through the fine wire of the magnets before the armature would have time to drop and throw in the cut-out. To prevent any possible damage during this brief interval, an auxiliary cut-out is inserted which at such a time opens a path for the total current around the magnets until the main cut-out can operate, when the auxiliary cut-out is itself thrown out of the circuit. On the double lamp the globe holder is secured by a thumb screw, the loosening of which permits the globe to be lowered until stopped by the nut on the center support rod. The globe holder on the single lamp is also secured by a thumb screw, and when lowered, is supported by a chain attached to the lower frame of the lamp. If desired, the double lamp is supplied with drop tubes for the lower carbons. The globe holder of the single lamp for indoor use is fitted with a dust pan to prevent sparks and dust dropping through the globe holder.

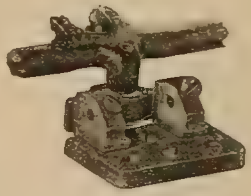


FIGURE 5.—THE CUT OUT.

When lamps are to be used indoors or in protected positions, sheet iron casings are furnished; but if they are to be exposed to the weather, especially near salt water or in a location where corrosion of the iron is likely to take place, the use of a copper casing is recommended. By simply pressing a spring clip on the upper side with one hand, the casing may be removed. All casings are finished in black enamel.

No solder is used in assembling the lamp, and no tool but a screwdriver is required to take it apart.

LEATHER BELTS FOR DYNAMO SERVICE.

ONE of the most attractive booths in the Machinery and Electricity building at the Trans-Mississippi Exposition is that of Chas. A. Schieren & Co., in the busy northwest corner of the building, and the most prominent feature of the exhibit is a monster perforated electric belt seventy-two inches wide. This is one of a great number of belts of that size manufactured by Chas. A. Schieren & Co., and is a striking example of the art of making large belts, in the manufacture of which this firm excels.

An immense hide is suspended from one side of the Schieren booth as an exemplification of their justly celebrated Dixie tannage. Alongside is a picture of their famous Dixie Tannery, Bristol, Tenn., the capacity of which is 60,000 heavy hides per year. The tannery is located in the heart of one of the best oak bark regions of the country, and the tannage is the old long process with pure oak bark. This, together with their high order of workmanship, is conclusive of the fact that they secure to their belts the longest possible life and wear in leather belting. There are several rolls of their high grade, short lap belting on exhibition.

The electric and perforated electric belting is well represented. This, the perfection in belting for dynamos and other swift running machinery, is too well known to need any description here. It is to be found in use in every city and almost every town in this country, and also very extensively in Europe, South America and Asia, and in fact all over the world. There is also a roll of link belting, showing the patent American joint, which enables the belt to conform perfectly with the crown of the pulleys, and enables it to run perfectly on odd drives, as, for instance, a "quarter turn."

Last, but not least, is noted another of this firm's many contributions in the line of progress, viz.: their "Giant" Lace Leather. This is gotten out solely for strength and durability, and regardless of its color, which is unique, and the demand for it is conclusive proof of its great and uniform success. It is a significant fact that on Oak Backs, Bellies and Shoulders, which are also represented in their exhibit, Messrs. Chas. A. Schieren & Co.

justly enjoy the same high reputation among shoe manufacturers as upon leather belting and lace leather in the immense community of belt users.

Space does not allow us to describe the rest of the exhibit, as, for instance, pump and valve leather, round solid, twist and patent solid belting, electric belt dressing and cement.

A visit to this attractive booth is bound to prove instructive to all users of leather, and, together with the interesting literature dispensed as souvenirs, it is bound to be of benefit and a great convenience to all seeking information in this line. Mr. Herman A. Giese is the representative in charge.

THE SNOQUALMIE TRANSMISSION CONTRACT.

CONTRACTS involving ten thousand horse-power are not common. Especially is this true when the agreement is to transmit this enormous amount of power over a distance of forty-five miles. And when the contract further stipulates that the losses in generators, transformers, and line shall remain normal, notwithstanding the difficulties involved, the agreement then becomes of still greater interest.

Such a contract has just been executed by the Westinghouse Electric and Manufacturing Company, in which they agree to comply with the above conditions. The plant is for the Snoqualmie Falls Electric Power Company, of Snoqualmie Falls, Washington. The power station is to be located at Snoqualmie Falls, forty-five miles from Tacoma, and thirty-one miles from Seattle, to which places the current is to be transmitted and then utilized by Westinghouse motors.

The contract involves the building and delivery at above points, of four three-phase, rotary armature, generators, having a normal aggregate capacity of 6000 kilowatts, and which are to be direct connected to water wheels; two seventy-five kilowatt "kodak" exciter dynamos, also to be direct connected to water wheels; high and low potential switchboards for main power station and sub-stations at Seattle and Tacoma, involving seventy-six marble panels with all necessary instruments, switches, etc.; high tension, oil-insulated, static transformers, having an aggregate capacity of 10,875 kilowatts; rotary transformers with a total output of 2700 kilowatts, and six type "C" motors developing 1600 horse-power, with adequate lighting protection at both ends of the line.

These machines, when installed, will make available for industrial, railway and lighting purposes the power of Snoqualmie Falls. The line potential will be 25,000 volts, and its current will be carried over bare aluminum wires to sub-stations where lowering transformers will sufficiently reduce the voltage for safe transmission within the corporate limits of the two cities.

CENTRAL ELECTRIC COMPANY IN THE WEST.

Mr. A. I. Neisser, representing the Central Electric Company, of Chicago, after spending five weeks in and about San Francisco, has returned to Los Angeles, where he will continue to conduct his office at 327 Fred J. Byrne Building, while his brother, Mr. Otto Neisser, will soon locate in San Francisco in the interests of the Central Electric Company as its representative for Northern California, Oregon and Washington. Further announcements will be made in this column of the San Francisco address, as well as of the staple and special electrical supplies of every description that the Central Electric Company handle.

WORLD'S LARGEST GAS ENGINE.

The largest gas engine in the world is claimed to be that recently built by the Westinghouse Machine Company. It is run on a modification of the Beau de Rochas cycle, and has a brake horse-power of 650 horse-power. The engine has three cylinders, each twenty-five inches in diameter, and a thirty-inch stroke, and runs at 145 revolutions per minute. Its economy is very marked, resulting in the production of a brake horse-power for eleven cubic feet of natural gas. Its operation is said to be highly satisfactory.

Trade Literature.

(Catalogues mentioned in this department will be mailed gratuitously on application to the concerns publishing them. When writing, mention THE JOURNAL OF ELECTRICITY. Where addresses are not given, they may be found through reference to the Advertisers' Index on page iii.)

"Improved Brush Lamps." A dainty, illustrated presentation of new and valuable improvements that have been made in the Brush lamp, with details and price list of parts of the same. 40 pages. *General Electric Company.*

"Electric Street Railway History." Part One. A 40-page brochure of especial value to street railway interest, being a review of the development of Westinghouse railway motors with reference to generating apparatus of direct current and alternating rotary types. Freely illustrated. *Westinghouse Electric and Manufacturing Company.*

"Electricity for Machine Driving." A timely treatise presenting briefly the many advantages to be gained by the direct application of electric power instead of lines of shafting and connecting belts. Invaluable to manufacturers interested in reducing their operating expenses. 24 pages, well illustrated with interesting applications of electric power in machine driving. *Westinghouse Electric and Manufacturing Company.*

"Keystone Electrical Instruments." No. X. A catalogue of 26 pages, illustrative and descriptive of Keystone voltmeters, ammeters, potential and current indicators, galvanometers, polarity indicators and ground detectors. A valuable feature is the portion giving formulæ and circuit connections for the use of voltmeters in measuring insulation resistance. *Keystone Electrical Instrument Company*, Ninth street and Montgomery avenue, Philadelphia.

TABLE OF CONTENTS.

Illustrated articles are designated by an asterisk (*); Editorials by a dagger (†); Passing Comment by a double dagger (‡), and Industrial by a section mark (§).

Electro-Economics

* Some Possibilities With Electric Plants, by C. O. Poole............ 70

Illumination

* Electricity in the Schilling Gardens, by R. W. Lohmann.......... 65
§ Improved Brush Arc Lamps.................................. 78

Industrial

Central Electric Company in the West.......................... 80
Leather Belts for Dynamo Service.............................. 79

Obituary

Dr. John Hopkinson, F. R. S.................................. 73

Personal

.... 73

Physics

Electrolysis of Water... 77

Telegraphy

Japan as an Electrical Center................................. 73

Trade Literature

.... 80

Transmission

Calculating Three-phase Circuits.............................. 73
§ Closing the Snoqualmie Contract............................. 80
† How Shall We Drive Exciters?................................ 74
* Measuring Three-phase Circuits.............................. 77
‡ Over-conservatism in England................................ 75
Paralleling Large Alternators, by Edward P. Burch............. 73
Synchronous vs. Induction Motors.............................. 76
Substitutes for Copper as a Conductor......................... 77
† The Burial of a Bugaboo.................................... 74

Transportation

‡ Statistics Concerning Electric Railways...................... 75

THE JOURNAL OF ELECTRICITY.

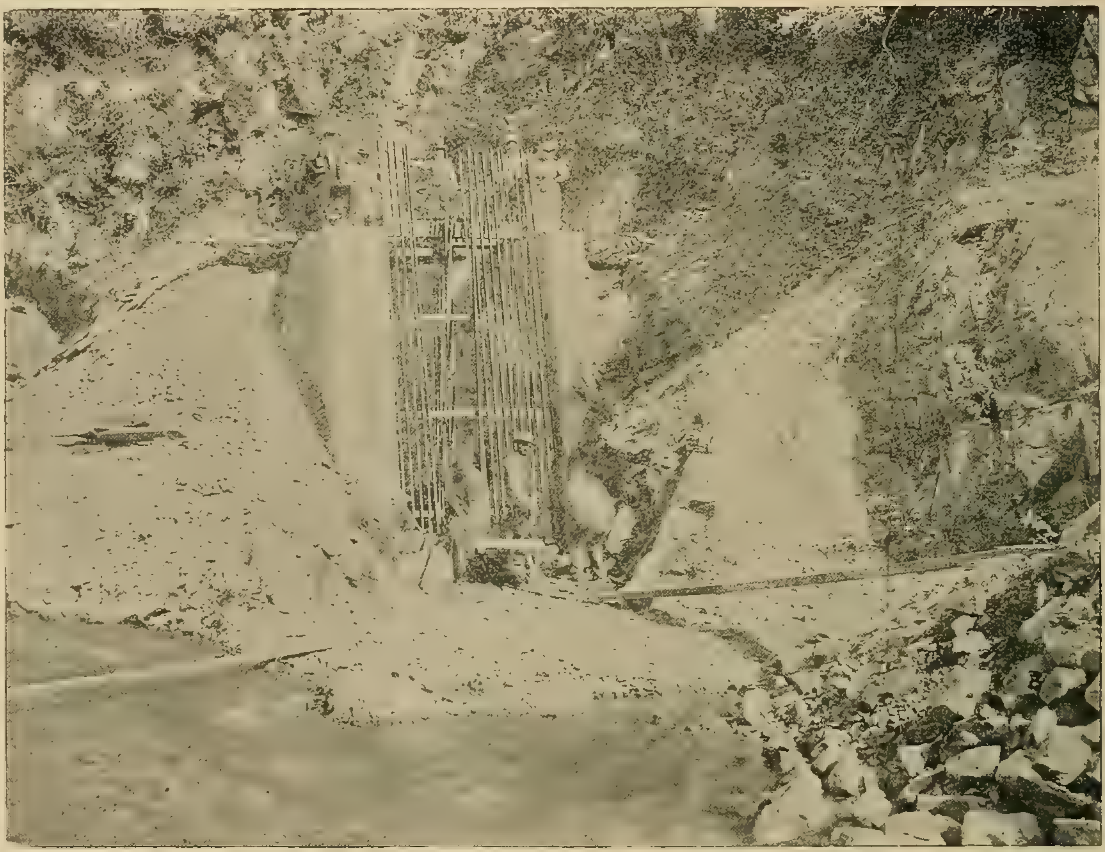
VOLUME VI., SAN FRANCISCO, NOVEMBER, 1898. NUMBER 5.

The San Gabriel-Los Angeles Transmission Plant.

BY GEO. P. LOW.

NOTE THE WOOD PIPE LINE IN THE MOUNTAIN FOREGROUND. CANYON OF THE SAN GABRIEL RIVER.

SPEAKING generally, the business of transmitting electrical energy over long distances has settled down to fairly well defined practices, in California at least, and ordinarily, one has but to know the kind of apparatus used, whether it be General Electric, Stanley, or Westinghouse, to be able to form a close idea of the principal features of the installation. Each company has its own types of equipment that are closely adhered to in almost every case, but the engineer who essays to visit the San Gabriel transmission will do well to leave many preconceived ideas behind unless he has been advised beforehand, for, whoever he may be, he will find the work clear through from the hydraulic development to the electric distribution to be a constant series of surprises, so that it is, in an engineering sense, the very quintessence of novelty, originality and boldness of design in many of its most important features. No one will gainsay the statement that it is a liberal education to spend a week or so in unraveling the many unprecedented combinations that are being worked, or have been worked through force of circumstances, in the most interesting installation about to be described, and it is without hesitation that the writer expresses the opinion that the Azusa-Los Angeles transmission is in some respects, the most remarkable to be found on the Pacific Coast, if not in America. Of all transmissions, the San Gabriel plant resembles the Hartford installation more than any other. Each is driven by water power, each has an auxiliary steam plant, and each delivers direct current, lighting and power service from rotary converters, but while the Hartford plant has a storage battery to equalize the load factor, the San Gabriel system gives or takes 500-volt direct current from the power circuits of the Los Angeles Railway Company, thus evening the load factor and affording a reserve of practically unlimited capacity. It is in the ingenuity of the combinations that result from the use of these three plants—water, steam and railway—that the remarkable novelty of the San Gabriel system, from an electrical engineering standpoint, exists. Many other transmissions exceed the San Gabriel plant in size, line voltage and distance, but none of them can approach it in what has been aptly termed its "electrical acrobatics." Be this as it may, it is certain that the engineers have, in gymnastic parlance, always "landed on their feet," and, as a result, the engineering of the San Gabriel plant is no less thorough than that of any other transmission in the country, while, beyond that, it is in many respects without a parallel, particularly in the broad resourcefulness of its designers, who have exercised exceptionally able engineering judgment in overcoming the greatest difficulties that could possibly beset an electric transmission during a season of most trying adversity. "Water is king" is a phrase that has become proverbial in central and southern California where a few brief weeks of bounteous rain and many long months of cloundless skies necessitate the utmost care in preserving the flow of every stream of fresh water, however small, and uniting these streams into irrigation ditches. This is indeed the land of "sunshine, fruit and flowers," but as Sahara has the sunshine, some portions of California, too, would be without fruit and flowers were it not for irrigation derived by untiring care and watchfulness from these self-same streams while yet in their parental mountains. Though most of the larger rivers carry surface water across the lowlands all through the year, some of them are "dry" rivers in summer; that is, during summer months the course of the river is marked by the dry, bleached gravel and granitic sand that shimmers with the heat of the sun as on the desert wastes. But a few inches below the surface is found moisture and in a few feet of digging water will seep in right merrily, while by going down stream a few yards seemingly immeasurable quantities of excellent water will be found percolating through the gravel on toward the sea. Such "dry" rivers are found only in lowland valleys, as in the mountain canyons there is surface flow all the year round, and these mountain rivers, so beautiful and innocent ordinarily, become torrential at times in winter, often rising from twenty to thirty feet or more in a single night, with waters carrying all before them in their wild rush down the canyon. It seems odd, in going up the San Gabriel canyon for instance, to drive on the dry portion of the river bed beside the flowing water and to pass under wire ropes, along which improvised cars are pulled to bridge foot passengers over at times of high water. The San Gabriel river is of this class, but rarely is the season so dry that the surface water entirely disappears down in the valley. The prudent engineer, though, gauges the capacity of a stream of water for power purposes by its minimum flow, even though that minimum be reached but once in a generation; and so, when the drouth of the present year came on, the San Gabriel company was not found unprepared for the emergency. For thirty years the water of the San Gabriel river has not been so low as during the summer just closed, nevertheless the plant began operations on July 1st, as announced, and satisfactory service has been continued ever since without a moment's interruption, despite seemingly insurmountable obstacles, among the least of which was the fact that it was a new company, with a new plant, in a new field, with new underground service delivered in part from new and untried electrical combinations. More than this, the business of the company increased so rapidly that within a month after operations commenced, the rated capacity of the plant had been reached, whereas it was not expected that this load could be secured in less than six months. At present every piece of apparatus connected with the delivery of direct current service is being run for a few hours every Saturday night as an overload of from fifty to sixty per cent. without evincing a sign of injury or hardly of overload.



A 580-FOOT TUNNEL RUNS BACK FROM THIS INTAKE.

HEAD OF THE WATER SYSTEM AT THE DAM SITE.

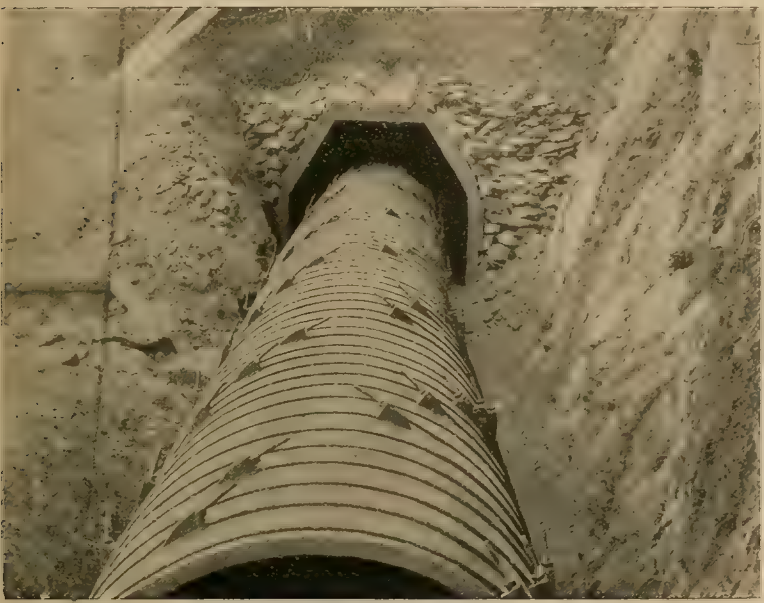
How these satisfactory results, so briefly set forth above, have been attained, forms one of the most interesting and instructive experiences in the history of electrical transmission installation, and to faithfully describe the engineering details of the plant is the purpose of the following pages.

THE WATER SYSTEM.

The width of the San Gabriel river at the head of the water system is close to four hundred feet, which measures the distance between the sides of the canyon. By wagon road, the intake is nearly nine miles from Azusa, a small station in the San Gabriel valley on the Santa Fé railroad, and eight miles from the power house, although the waterway is less than six miles in length, but the winding character of the river, along which the road follows, easily accounts for the difference. The intake is on the easterly side of the river at the base of a mountain that rises to a height of from three to four thousand feet above, and the peculiarity of the intake is that the water, after passing the strainer bars and headgates, makes a straight perpendicular drop of twenty feet, whence it continues horizontally in a southerly direction through a 580-foot tunnel, which is the first of the series of thirty-eight tunnels in the waterway. At first glance it seems as though the bringing out of the first tunnel at a point twenty feet below the level of the river at the intake must have been an error, for it reduces the head of water at the power house by that elevation; but when it is remembered that in summer time a material part of the flow of the river is in underflow that seeps through the sand and gravel beneath the river bed, and that this underflow should be thrown into the canal as well as the surface flow, the wisdom of the engineers in building the tunnel as located will not be questioned. The underflow must, then, be diverted into the tunnel, to do which a submerged dam is to be built during the coming summer across the bed of the river immediately below the intake, and during the summer just closed, shafts have been sunk across the river bed for the purpose of determining the contour of bedrock preparatory to the awarding of the contract for the building of the submerged dam.

THE SUBMERGED DAM.

These shafts are eight in number, being in line across the canyon, and fifty feet apart, and work on the sinking of two of them, which appear to be at a location where a subterranean ravine has been cut in the bedrock, has been abandoned for the winter, but will be resumed again next spring as soon as the river is low enough to admit working. The sinking of these shafts, though troublesome, has not been an unmixed evil, for during the past summer from two hundred to two hundred and fifty inches of water have been lifted therefrom at a depth of about thirty feet, and the water thus raised has been thrown into the canal. This has been a material gain, as the water reaches the power house under a head of four hundred feet, and as the pumping at the dam site has been done by steam, with drift wood as fuel, making the cost of pumping very low. Bedrock has been reached in all but two of the shafts, and its average depth for the remaining six shafts is slightly above twenty feet. No doubt is felt but that bedrock will be found in the two shafts referred to at depths of less than sixty feet, in which event some sixty or seventy-five feet of the length of the dam will have an average height, or rather depth, of fifty feet, while the remaining three hundred odd feet of the dam will have an average depth of not more than twenty-five feet.

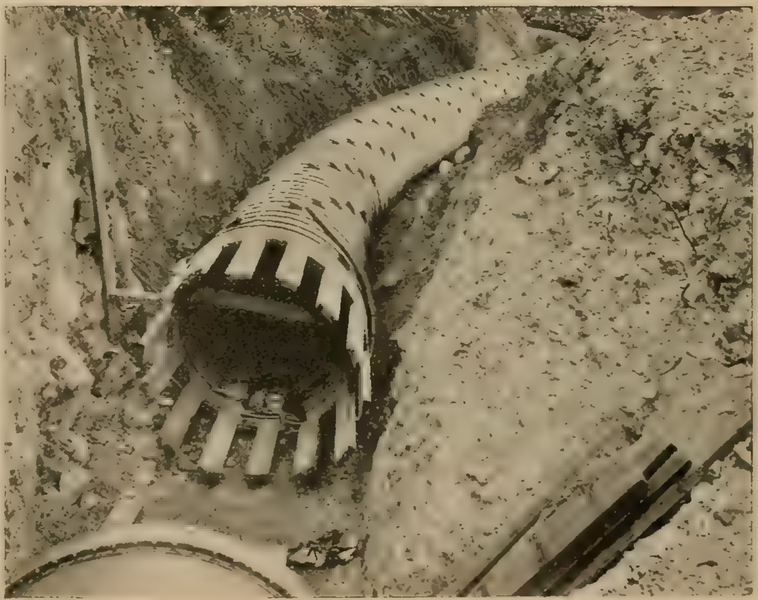


THE STAVE PIPE IS CARRIED THROUGH SHORT TUNNELS.

The dam so constructed will be of concrete with an average thickness of perhaps twenty feet at the base, tapering to a width of probably six feet at the top; this top or crest, of course, being level with the surface of the gravel that forms the bed of the river. The engineer's plans show that the dam is to have a radius of four hundred feet and that a catchment tunnel will be constructed along its inner surface along a line on a level with the first tunnel of the water way some twenty feet below the surface of the river bed; into this catchment tunnel the underflow will seep through percolative walls whence it will be carried into the main waterway direct, and it is estimated that an increase of at least six hundred inches of water will be made available as a result of the building of the submerged dam as proposed. It is possible that the dam may be carried up to an elevation of thirty feet above the river bed, which would give a catchment area nearly four miles long, but the company's plans are not matured in this direction as yet.

A SUPERB WATERWAY.

A remarkable feature in the water system of the San Gabriel Electric Company is the fact that the water is carried either through concrete work, masonry, or closed pipe from beginning to end. No attempt is to be here made to give actual figures concerning any portion of the plant, as complete and accurate information of this nature will be found in the table of engineering data given at the conclusion of this article; but it is of interest to note that the water system contains over twenty thousand feet of tunnels, nearly nine thousand feet of wood pipe, and over fifteen hundred feet of concrete culvert. No open ditching, in the ordinary sense of the term, is used, and the system has no fluming; the tunnels are lined on the sides and bottom with concrete varying from four inches up to thirty-six inches in thickness, according to the characteristics of the rock, and, except where firm rock is pierced, the tunnels are arched with masonry. The mountains are mainly of decomposed granite, and one tunnel that had a length of above two hundred feet, was found to be filled with loose, finely broken rock—just about as rock comes through a rock breaker—although for two rods at each end of the tunnel the rock was of ordinary kind. Naturally, the piercing of a tunnel through such formation was found to be a very difficult piece of work. The longest tunnel in the system has a length of 1610 feet, several hundred feet of which are run within from fifteen to fifty feet of the perpendicular wall of the canyon, and in cutting this tunnel work was commenced simultaneously at five different points, viz.: at the two ends and at three points in the canyon from which lateral tunnels were run in the proper distance whence work on the main tunnel was continued at right angles thereto. So far as is known there is no leakage whatever in any portion of the waterway, and, to the contrary, there is an in-seepage into the tunnels at points that are not arched which amounted at no time during last summer to less than twenty-five inches; in other words, at least twenty-five inches more water reached the power house than was turned into the intake at the dam site, but this is not suprising to one who has investigated the extraordinary thoroughness of the waterway construction; even the pores of the concrete have been filled with a penetrating compound to prevent loss of water. Where open ditches would ordinarily be run, wood stave pipe and arched culverts have been used, and with the exception of a very few rods of open concrete ditching, the only points along the waterway where evaporation is possible are at the sand gate, penstock, and at the ends of the wood stave pipe line. Indeed, so perfectly constructed is the company's water system that the Duarte and Azusa irrigation districts, which hold the prior right to the waters of the San Gabriel river, have granted



ALL STAVES BREAK JOINTS AS SHOWN ABOVE.

to the San Gabriel Electric Company the perpetual ownership of one-tenth of the flow of the river in consideration of the thoroughness of the water development. The value of this grant will be recognized when the fact is known that in that section of southern California water has a value of $1000 a miners inch.

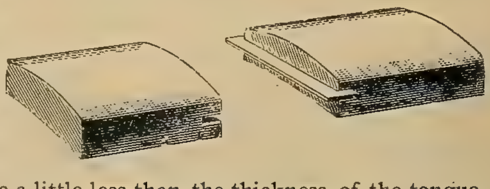
The exceedingly broken and rough character of the canyon made the problem of designing an economical water conduit that should be tight, permanent, and not subject to injury or interruption, a difficult one to solve, for such were the requirements for the waterway in that portion of the system outside of the tunnels; nevertheless the engineers succeeded in finding a most satisfactory solution of the question in the use of wood stave pipe.

AT EACH END OF PIPE LINE THE WATERWAY DROPS.

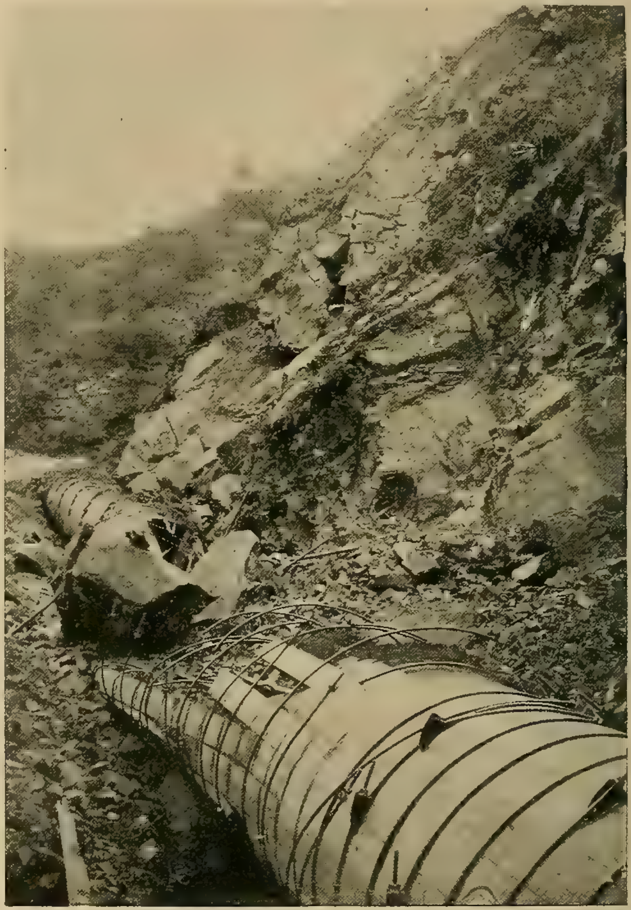
WOOD STAVE PIPE. All pipe, except the last short section leading down from the penstock to the power house, is 48-inch wooden stave pipe, laid uniformly ten feet below hydraulic grade, and is buried in the side of the mountain. As this kind of pipe has earned its place among the recognized and approved standards in the western United States, and has, owing to its comparatively low cost, made many propositions financially possible that could not otherwise have been carried out, and as it may not be so well known outside of the section of the country where it originated, a detailed statement of its construction and merits will, it is believed, be welcomed.

A CHARACTERISTIC BIT OF MASONRY.

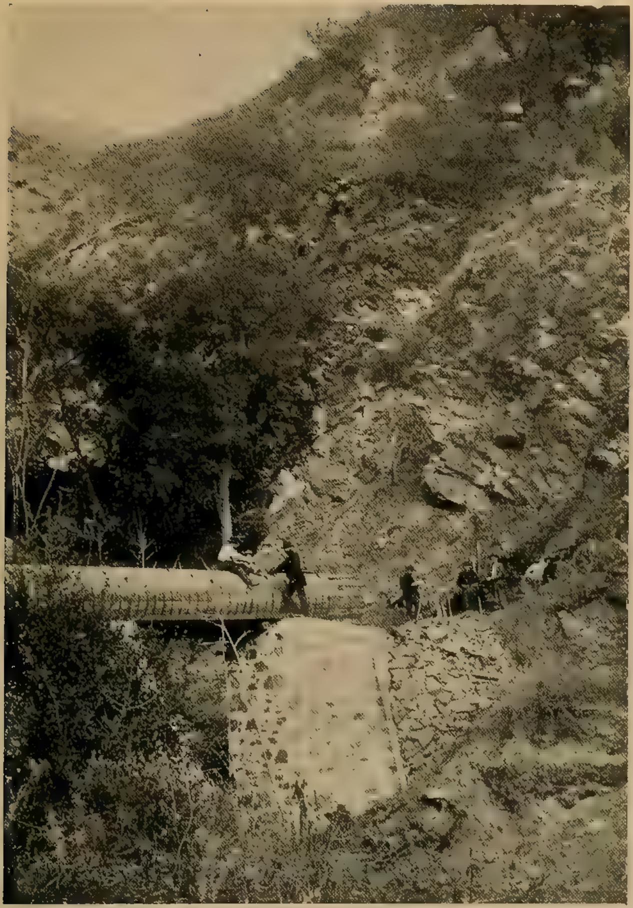
The pipe is a continuous cylindrical tube consisting of wooden staves, placed so as to break joint, and derives its strength and rigidity from the steel hoops surrounding it. The staves are of clear wood, usually California redwood, dressed on the flat sides to circles and on the edges to radial planes, a certain number completing a true circular ring, thus forming the shell of the pipe. The staves are cut off square and the ends are slotted for the insertion of a metallic tongue, as shown in the adjoining cuts. The width of the slot is a little less than the thickness of the tongue, and the depth is less than half its width, so that when in place and with staves abutting, the edges of the tongue cut into the bottom of the slots and into the sides of the adjoining staves, thus securing a tight butt joint.



The bands consist of round steel bolts or rods, with a head at one end and a thread, nut and washer at the other end, the two ends being united by a malleable iron shoe. The bolt has a cold pressed thread of greater strength than its shank. The shoe, which fits close upon the pipe, has an interior shoulder for the head of the bolt and an exterior shoulder for the nut, and is of such a shape as to leave the entire band in a plane perpendicular to the direction of the pipe. Round bands are preferable to flat ones, as, for equal strength, they expose less surface to rust and, moreover, when the wood swells, they imbed themselves into the staves more satisfactorily than flat bands. The turning of the nut tightens the band and presses the staves together, the effect being that when the bands are at proper tension a wooden cylinder is produced of great strength and which for rigidity against collapsing is only equaled by cast-iron pipe. The spacing of the bands varies, depending upon the pressure at any one point. Where the pressure is the same all along the spacing remains uniform as in the San Gabriel pipe where the bands are placed ten inches center to center. The pipe can be laid in curves the radius of

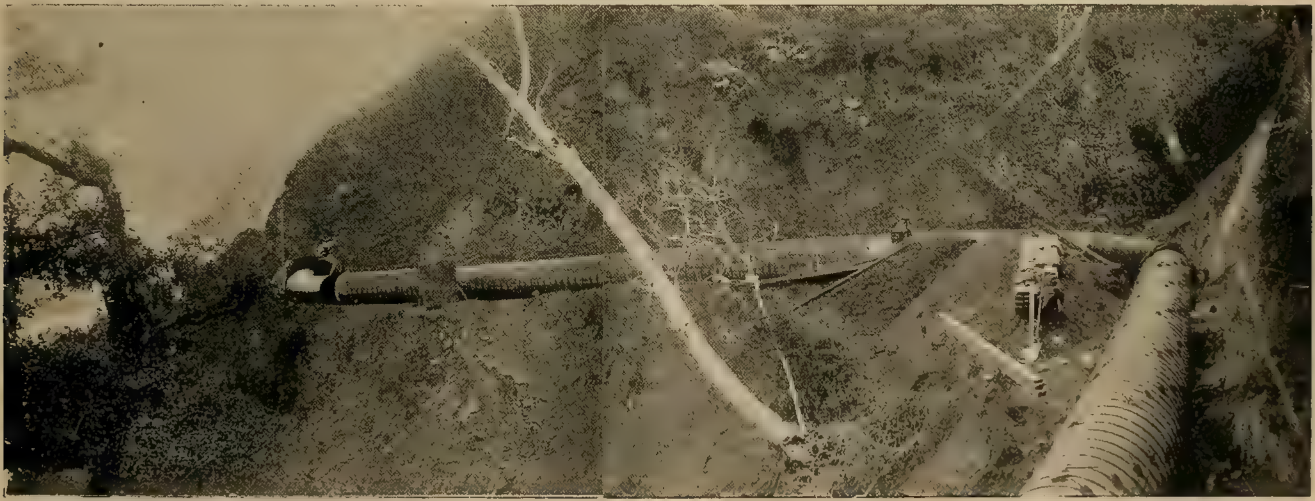


IT COST ONLY $14.60 TO REPAIR THIS BREAK.



HOW THE RAVINES ARE CROSSED.

which depends upon the diameter of the pipe and the thickness of the staves. The sharpest of the curves of the San Gabriel pipe have a radius of 125 feet. Where sharper curvature could not be avoided, steel elbows were introduced of slightly larger diameter, having a riveted bell or socket to connect with the wooden pipe, the space between the pipe and bell being partly filled with oakum, driven in hard, the remainder being filled with clear Portland cement as shown in the accompanying sectional drawing.

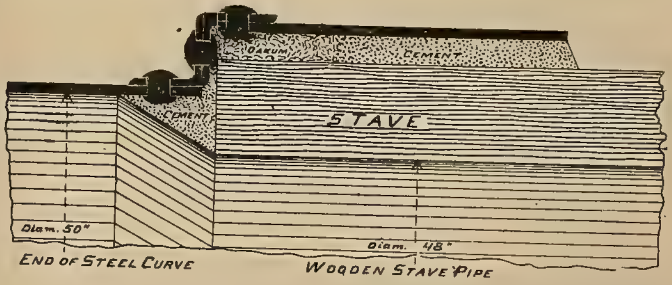


STEEL PIPE IS USED AT BENDS.

A COMPOUND CURVE ON THE WOOD PIPE LINE.

The construction of this pipe is apparently quite simple, but years of experience have proven that great skill and conscientious care are required to produce water-tight work and that there are a great many niceties to be observed in construction which make all the difference between success and failure.

Connection is made between the pipe and each tunnel by means of a small masonry basin with its bottom sloping from the grade of the tunnel to the grade of pipe ten feet lower. The water in these basins stands always well above the top of the pipe, and even when the flow ceases altogether, the pipe remains entirely filled and under pressure. While the pressure upon the San Gabriel pipe is very light, it should be stated, for the full understanding of this subject, that wooden pipe can be built for pressures up to 200 feet and that many heavy pressure pipes are now in successful use. Further, that when carefully designed and constructed wood stave pipe has a record for entire absence of leakage unsurpassed by any other class, as has been fully established by accurate measurements on long lines of pipe.



DETAILS OF THE STEEL AND STAVE PIPE JOINTS.

In a paper on wooden stave pipe, by A. L. Adams, appearing in the Proceedings of the American Society of Civil Engineers, for September, 1898, the relative standing of the principal qualifications governing the economy of different classes of pipe is set forth in the following table:

	COST.	LIFE.	CAPACITY.
1	Stave	Cast Iron	Stave
2	Steel Riveted	Stave	Cast Iron
3	Cast Iron	Steel Riveted	Steel Riveted

and the reasons for this classification are there fully explained. That stave pipe promises a far longer life than steel riveted pipe is explained by the fact that the staves remain at all times saturated and will last indefinitely, thus leaving the steel hoops as the only perishable portion of the pipe; that the steel in the hoops occurs in a concentrated form which exposes but little surface for rusting, the opposite being the case in the plates of a riveted pipe, and that a riveted pipe usually becomes useless and must be abandoned when less than one per cent. of the metal is rusted away because this loss occurs in small pitholes, causing leakage through the pipe, while the hoops on the wooden pipe may suffer a loss of seventy-five per cent. before leakage would result. Mr. Adams further publishes a table of cost for the three different

ALL MASONRY IS OF MOST SUBSTANTIAL CHARACTER.

FROM TUNNEL TO CULVERT.

classes of pipe considered, clearly showing the difference in favor of wooden stave pipe. No general tabulation of this kind can take into consideration all circumstances governing economy, and special cases will often develop further advantages in the use of wooden pipe, sometimes more or less unexpected. Take the San Gabriel pipe line as an instance. It is located on the steep side of a canyon at an elevation of from 20 to 450 feet above the stream. Clearly it would have been an expensive proceeding to hoist heavy lengths of riveted pipe to the line of ditch. The heaviest single part of the wooden pipe did not exceed fifty pounds in weight, and the load on the temporary tramways, laid on the mountain side, could be made as small as desired and men could readily carry or truck all material from the head of the tram along the grade.

During construction and before the pipe could be back-filled, or had been filled with water, a boulder on the mountain slope above became loosened and struck on top of the pipe, as illustrated on page 84. The boulder weighed many tons, the view having been taken after about two-thirds of it had been blasted away. All tramways and tools had been removed, and had riveted pipe been used it would have been very tedious and expensive to make repairs. The accident occurred on January 24th last; work on the repairs of the pipe was commenced on the day following and completed January 26th at a total labor cost for pipe work of $14.60. All but two of the bands could be used again, new staves were easily carried up the mountain sides and the undamaged portions of many of the old staves were sawed off and used in building the pipe further down the line.

The carrying capacity is another item that greatly affects economy and is too often entirely ignored in comparisons of first cost. As compared to *new* riveted pipe, stave pipe will carry from ten to forty per cent. more water, the difference being greatest for large size pipe. This difference in favor of wooden stave pipe becomes still more important after some years of use when the wooden pipe shows no diminution of flow, and a riveted pipe, by reason of tuberculation, may easily lose twenty per cent. of its original capacity. A wooden pipe, then, consumes less head in friction, thus leaving more pressure available at the wheel, or it may be made of smaller diameter to do the same work as a riveted pipe.

In comparison with flume, wooden pipe will generally be found to be more expensive in first cost, unless the flume requires trestling, but the two cannot reasonably be placed on the same basis, for while the pipe has an insured life measured in scores of years, the flume requires constant renewal. By reason of its liability to injury and necessity of frequent repairs, the flume cannot but be looked upon as a most objectionable link in a water power plant where interruption is the one thing to be guarded against. There is the further objection to flumes that they constantly leak and that the exposed water surface causes losses from evaporation, which may become serious matters where the water has to be conducted for great distances.

No doubt whatever exists then, that the use of tunnels and pipes on this extremely rocky and steep mountain side is a great advantage over the customary flume and ditch, since they are not so likely to be disturbed by falling rock, land slides, washouts, etc. In this, as in every other portion of the plant, no expense has been spared to make everything of the highest quality. The engineering and materials have been of the best throughout, and the long life of every portion of the plant will prove the wisdom of the use of such uncommonly excellent materials and workmanship.

The forebay is located on the side of a steep mountain that forms the easterly side of the mouth of the canyon, and the pipe line that carries the water thence to the power house, a little over eight hundred feet below, is of thirty-six-inch double-riveted steel, thoroughly anchored in cement abutments and laid in an air line

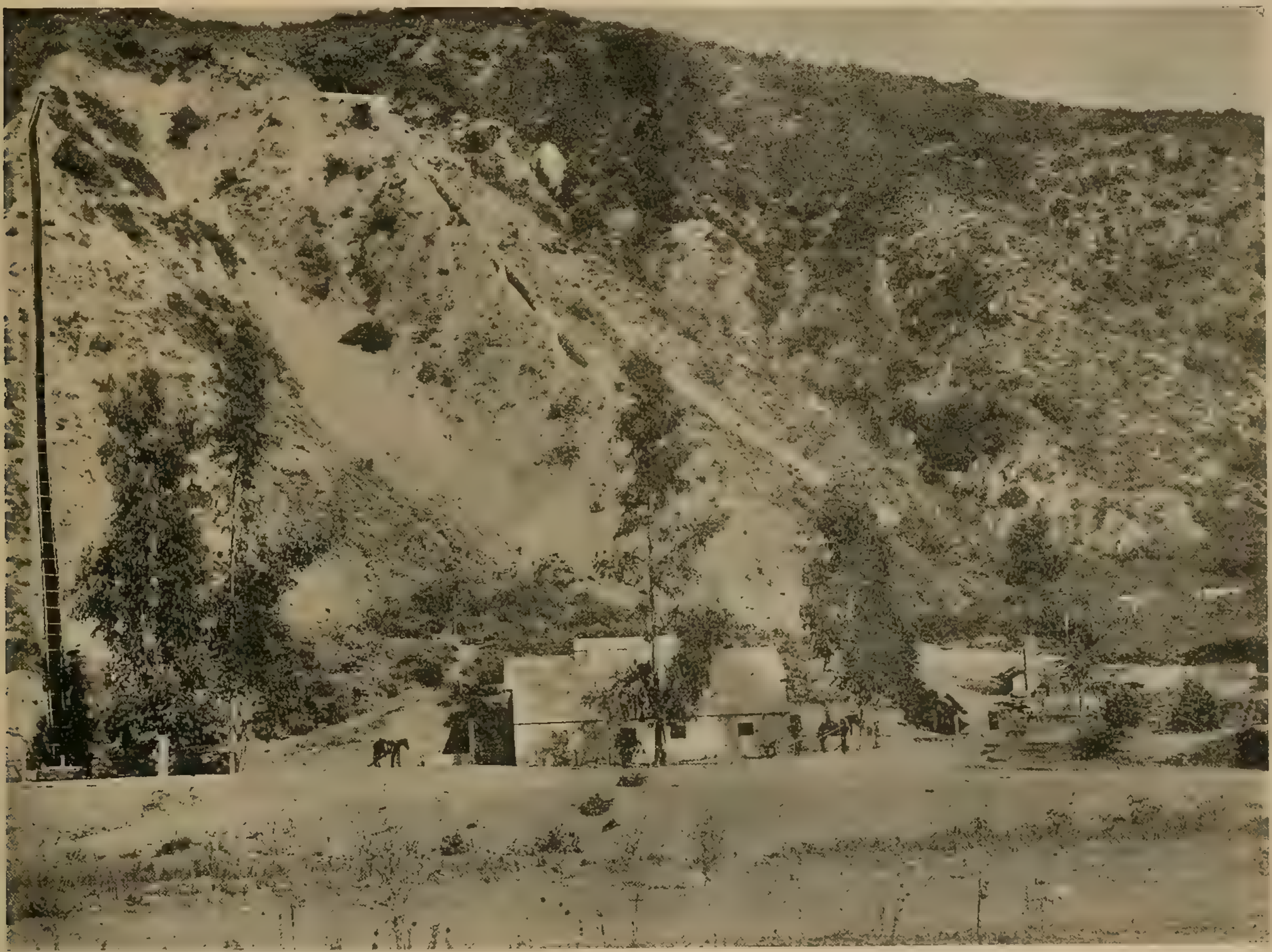
OVERLOOKING THE MOUTH OF SAN GABRIEL CANYON.

CONCRETE WORK AT THE PENSTOCK.

over its entire length until the power house is reached. There it turns at a right angle through a quadrant having a radius of fifty feet, running into and parallel with the lower side of the power house where it extends into a receiver of half-inch riveted steel. No air chamber is used, but instead, the receiver is supplied with two three-inch relief valves. The gradient of the pressure pipe line from the penstock to the power house is very steep, reaching in places to above fifty degrees. At the left, in the engraving below, is shown the wooden flume which carries surplus water from the penstock to the permanent weir in the tail race.

THE POWER HOUSE.

It is singular how abruptly in many places throughout southern California the low lands terminate and the mountains begin. About one mile to the north of Azusa is the power house, still down in San Gabriel valley proper, while its penstock, eight hundred odd feet distant by way of the pipe line, is up on the mountain side. Drawing One gives a comprehensive idea of the arrangement of the power house, from which it will be seen that it is composed of three apartments extending in the direction of its length. The apartment furthest from the mountain side contains nothing but the impulse water wheels with their gate valves, regulator hoods and housings, and the receiver. The center of the building, which forms the main portion, contains the generators, exciters, switchboards, and water wheel governors, while the third apartment, constituting the transformer house, contains the raising transformers, high tension switching devices, lightning arresters and choke coils, and from this room the line wires are carried out through a usual form of opening. A gable roof covers the whole power house, and in the center apartment, where the roof is highest, a traveling crane of sufficient capacity to handle any of the machinery, is installed. All walls of the power house, even the two inner ones dividing the building into compartments, are of massive concrete work, and as the roof is of corrugated iron supported on iron trusses, the building is both substantial and thoroughly fire proof. It is, withal, one of the best arranged power houses to be found on the Pacific Coast.

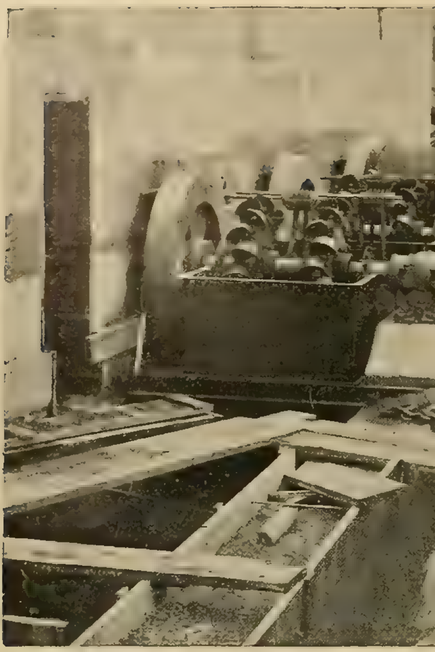


PRESSURE PIPE LINE DOWN THE CENTER;
OVERFLOW WEIR AND RACE AT THE LEFT.

SAN GABRIEL POWER HOUSE,
AZUSA, CALIFORNIA.

The receiver presents two features which, though not innovations, are unusual in electric transmission work; viz.: it is placed along the sides of the wheels, instead of above, and the nozzles are taken at right angles from laterals which are also at right angles to the receiver. These laterals are, moreover, supported in masonry at each end, and the idea which led to this departure from conventional practices was that it would eliminate the so-called warping strains due to the placing of goose necks on the under side of the receiver. As installed, all strains from the jets are taken by masonry in direct lines so as to relieve the receiver therefrom entirely. A further feature of interest is the fact that four double sets of Tutthill water wheels are used, and as the installation is the first large electric transmission to be so equipped, the wheels call for more than passing reference. The ground floor plan of the station, seen in Drawing One, shows that the four sets of water wheels are installed with their shafts parallel and extending through a concrete wall, each for direct coupling to its respective generator. Each wheel shaft carries a three-ton fly wheel placed next to the wall, and each set consists of two wheels, each supplied from an individual nozzle, and controlled by an independent gate valve; two of the sets are provided

TUTTHILL WATER WHEELS.



SHOWING RECEIVER, BUCKET, AND FLY WHEEL ARRANGEMENT.

HYDRAULIC WORK DURING CONSTRUCTION.

with cut-off hoods in addition. The controlling valves are arranged with slow-moving worm gears so that they can not be suddenly shut off, thus rendering water hammer improbable. No further wheel equipment has been placed in this section of the station. The receiver has no air chamber, but is provided with two three-inch safety valves, a manhole, and a mud blow-off valve.

A clear idea of the water wheel equipment will be had by reference to the illustrations on page 90. The cast iron framing around the inner bearing in the lower cut, shows the line of the dividing wall, between which and the wheel casing the fly wheel intervenes. The two hand wheels in the upper left hand corner give individual control of the wheels through the gate valves; the governor is driven from the main shaft by two lines of belting; a flexible coupling is afforded through the usual form of rawhide links, and the bearings are self-oiling and self-aligning. The buckets, however, differ radically from those used in any other impulse wheel. The object of a water wheel of this type is, obviously, to convert the energy of a stream of water working under pressure into useful work, and to utilize this energy to its full value, the ideal bucket is so shaped that the jet section will enter the bucket without much deflection, agitation or turbulence. A small loss from heat, friction and change of angles due to the circular design of the wheel, can not be avoided, and the velocity of the water as it leaves the buckets is a material factor; hence, in seeking the highest efficiency, the bucket surface must not be at too great an angle where the jet enters, and the bucket must be of such form as will not in any way separate, agitate, flatten, or split up the jet. To the contrary, the bucket should be so curved as to avoid all corners or sharp angles; it should be amply deep and of such form that when the jet enters the bucket, the bucket will still hold the full section of the stream until its energy is converted into motion, when the water should be discharged without velocity and without any interference with the water from another bucket or any barrier whatever. The construction of the Tutthill water wheel bucket is such that it embodies all of these features as near as it is possible to do so and still be consistent with the best mechanical practices. The number of buckets as well as the wetted surface, is small, and hence the friction is smaller than in any other bucket of the same class. The discharge lip is parallel to the rim, and, when run at proper speed, there is no velocity whatever to the water under discharge.

In Tutthill wheels, the buckets are made in rights and lefts and discharge alternately from each side of the wheel, thus permitting the easiest possible escape of the water. This form of construction also enables the jet to strike the bucket at a tangent without splitting, that is, at its full cross section; and herein is found a distinct advantage: for while, in the more familiar types of tangential wheels, the jet is split on entering the bucket, in the Tutthill wheel there is no loss of energy from this source.

The manufacturers claim that the Tutthill wheel has a very high efficiency, in support of which they cite a test where, with a 3⅜-inch nozzle under a head of 390 feet, an efficiency of 85.7 per cent. was realized. Another test made with a special test wheel having a diameter of 36 inches and supplied with water from a

WATER IS FLOWING INTO THE AZUSA IRRIGATION SYSTEM.

FRONT VIEW OF THE POWER HOUSE.

⅝-inch jet under a 200-foot head, is said to have given a Prony brake efficiency of 91 per cent., the wheel and shaft weighing 62 pounds. In another case a 4-inch tip under a 54-foot head is stated to have given an efficiency of 80 per cent., while under a head of 180 feet an efficiency of 85.22 per cent. is claimed when using a 2½-inch nozzle. These are, as stated, the manufacturers' claims, but in the following table is presented the results of a series of tests made by the general manager and the consulting hydraulic engineer of the San Gabriel Electric Company, and the representative of the Oakland Iron Works, which manufactures the Tutthill wheel.

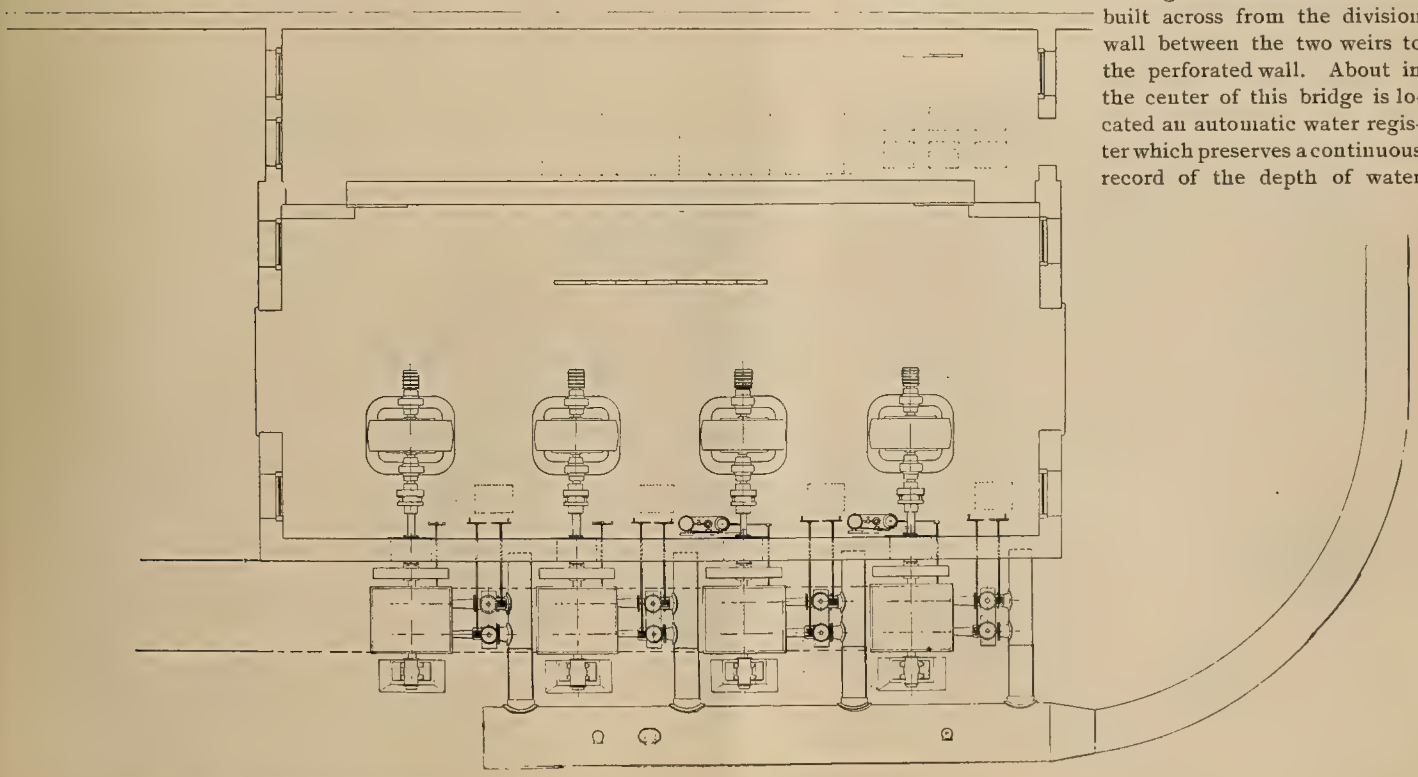
Number of unit....	2	2	2	4	2	2	2	R P M
Working head.....	390	389	392	390	390	390	....	430
Static head........	400	400	400	400	400	400	....	430
Size of tip used....	One 2⅞-in.	Two 2⅞-in.	One 2⅝-in.	Two 2⅝-in.	One 3⅛-in.	One 3½-in.	Two 3⅛-in.	430
Cubic feet of water discharged.......	366.9	733.8	316.8	633.6	441.5	577.78	883.04	430
Theoretical h. p...	270.6	541.2	234.0	468.02	326.12	426.78	652.24	430
H'rse-p'wer output	227.30	454.60	197.30	394.6	275.2	323.4	550.4	430
Friction load of wheel in h. p....	10	10	10	10	10	10	10	430
Efficiency of wheel	84	84	83.03	84.10	84.3	84.3	85.8	430
Per cent. of load ..	50	100	35	60	60	64	125	430
Per cent. of load change in testing governor	20	50	75	100	....	....	....	430
Per cent. of variation in speed	1	1½	3	7	....	....	....	430

It is interesting to note, in this connection, the extraordinary degree of care that has been exercised by the engineers of the San Gabriel plant in so laying out the hydraulic system that the water delivered from the tail race to the irrigation systems below shall be under measurement at all hours of the day or night, and that these measurements shall be as accurate as it possible for human ingenuity to make them. After being used at the power house, the water is delivered to the Azusa and Duarte Irrigation districts, each in proportion to its interest in the waters of the San Gabriel river, and the contract between the San Gabriel company and these districts obligate the former to preserve the equitable division of the water, even to a fraction of an inch. To do this, some three feet in head was sacrificed in order that a weir dam could be built into the tail race.

A PERMANENT WEIR.

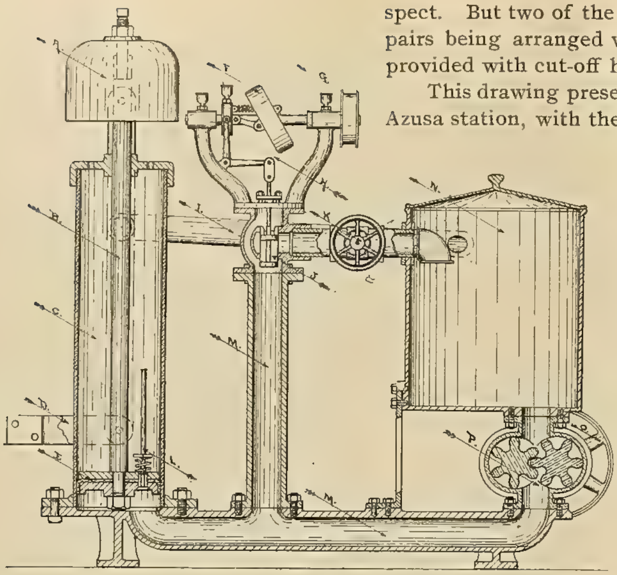
MEASURING WEIR IN THE TAIL RACE.

The above engraving shows this weir dam as it appeared before the water was turned in. The large open canal in the immediate foreground is the tail race, probably twenty feet beyond the wheel pit, and at the right near the end of this canal is the pit in which the overflow from the penstock is water-cushioned after its wild rush down the flume on the side of the mountain. Directly opposite this cushioning pit is a wall with about thirty openings placed well below the water level so that no disturbance from the water in the tail race will reach the water in the basin of the weir dam on the opposite side of the wall. This engraving, and the second one on page 88 are from photographs taken at diametrically opposite points; that above being taken from the bridge in front of the power house, and that on page 88 being taken from just beyond the head gate in the weir delivering water to the Duarte canal. The larger of the two weirs, therefore, delivers water to the Azusa district. Since the photograph was taken, a head gate has been placed on the Azusa weir as well, and a bridge-like structure has been built across from the division wall between the two weirs to the perforated wall. About in the center of this bridge is located an automatic water register which preserves a continuous record of the depth of water



FLOOR PLAN OF THE POWER HOUSE

DRAWING ONE.



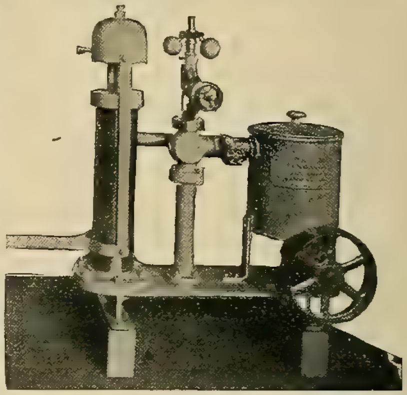
SECTION OF TUTTHILL GOVERNOR.

flowing over the weir. It shows the depth of the water without reduction on a chart that requires renewal weekly. The water used by the wheels in the test above given was measured by this permanent weir.

THE GOVERNOR.

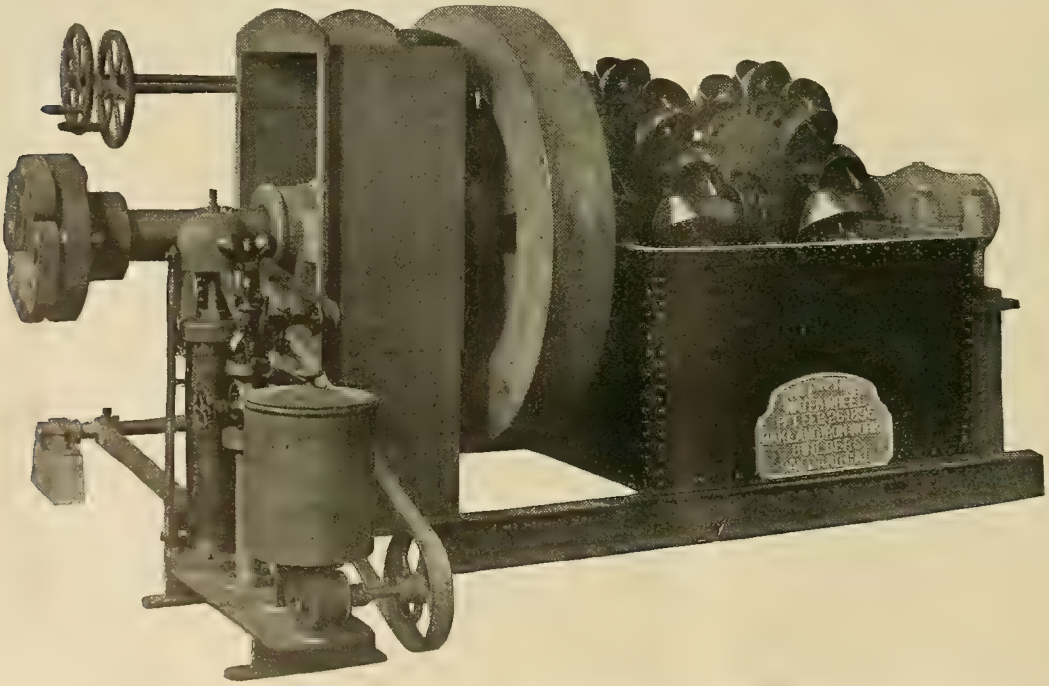
No one but inventors, manufacturers, and sales agents profess to believe that a perfect water wheel governor is in existence, hence every new mechanism of the kind that is placed on the market is closely scrutinized in the hope of finding an improvement in some feature on the existing forms of wheel regulator mechanisms. The Tutthill governors used in the San Gabriel power house not only possess the interesting features of newness, but they embody the highly desirable qualification of originality, simplicity and practical instantaneousness of action. It is all-mechanical and contains no delicate parts necessitating nicety of adjustment or eternal vigilance in care. While under test, the governors were subjected to violent changes of load at the Azusa power house, as will be shown, and there is a marked unanimity of opinion among the officials and employees of the company that the governor used is without a superior in any respect. But two of the four pairs of wheels are equipped with governors, the remaining two pairs being arranged with nozzles controlled by levers for hand regulation. All nozzles are provided with cut-off hoods.

This drawing presents a sectional view of the Tutthill water wheel governor as used in the Azusa station, with the exception that a tachometer type of actuating mechanism is used on the governor head, instead of the ordinary form of fly ball governor as installed. For the sake of simplicity, this governor head, carrying the parts lettered *F*, *G*, and *H*, is given a quarter turn in the sectional drawing. The piston *B*, traveling in the cylinder *C*, carries at its upper end the weight *A*, and at its lower end the plunger head *E*, while from either side of the weight *A* are long links shown in the photographs below, by means of which the motion of the piston is transmitted to the lever *D* controlling the nozzle cut-offs. Separate belts from the generator shaft drive the governor pulley *G* and the pump pulley *O*. The motions utilized in the governor head, two parts of which are lettered *F* and *H*, are practically identical with those of a tachometer, and the position of the swinging disc *F*, is transmitted by the means shown in the diagram to the valve *J*, which is under a balanced pressure by reason of the passage *I*. *N* is a reservoir containing either oil, or oil and water, or both, as preferred, and the liquid is kept in constant circulation by the pump *P* which forces it through the pipe *M* and the valve *J* back into the tank, or beneath the piston head *E*, or both, as the exigencies of governing may necessitate. Behind the valve casing is shown an overflow pipe which, as a precaution, will deliver any liquid that may get above the piston head into the tank. *K* is an ordinary gate valve which may be used, if desired, for shutting down the water wheels by means of the governor.



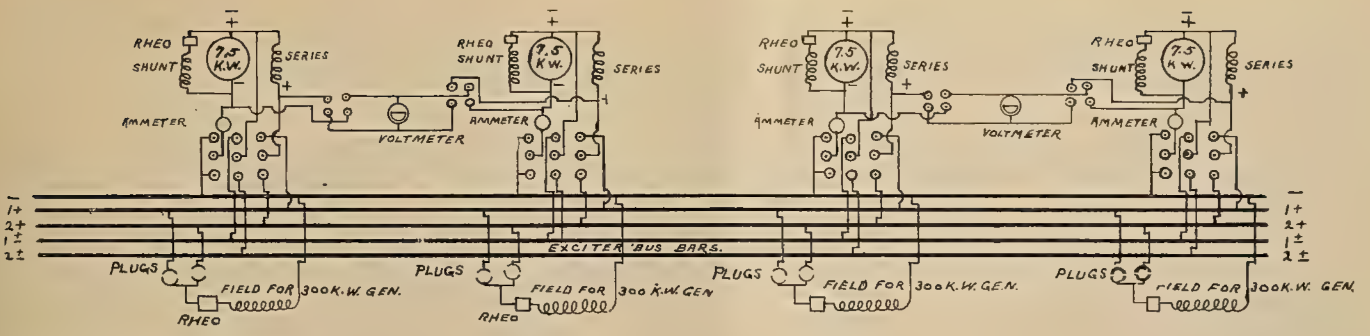
THE TUTTHILL GOVERNOR.

When the parts are in the position shown in the diagram, the cut-off hoods are entirely off the nozzle and the set of wheels is carrying a full load. The throttling valve *J*, being open, admits the passage of the entire output of the pump into the reservoir. Assuming now that a portion of the load drops off, the speed will tend to increase and the change in the position of the disc resulting therefrom will close the valve *J* proportionately, thus choking the delivery, which, being incompressible and practically irresistible, finds relief in raising the piston head *E*. This, in turn, raises the lever *D* and throttles the nozzles through the cut-off hoods. As the speed of the wheels is restored to normal, the valve *J* also returns to its normal position, which is such that it admits just enough liquid into the discharge pipe to keep the hydraulic pressure in the pipe *M* at such a point as will hold the piston head *E* in the position in which it was placed by the last movement. If, however, an increase of load should now come on re-



A SHOP VIEW OF A COMPLETE SET.

THE TUTTHILL WATER WHEEL AND GOVERNOR.



CIRCUIT CONNECTIONS OF THE EXCITER PANELS.

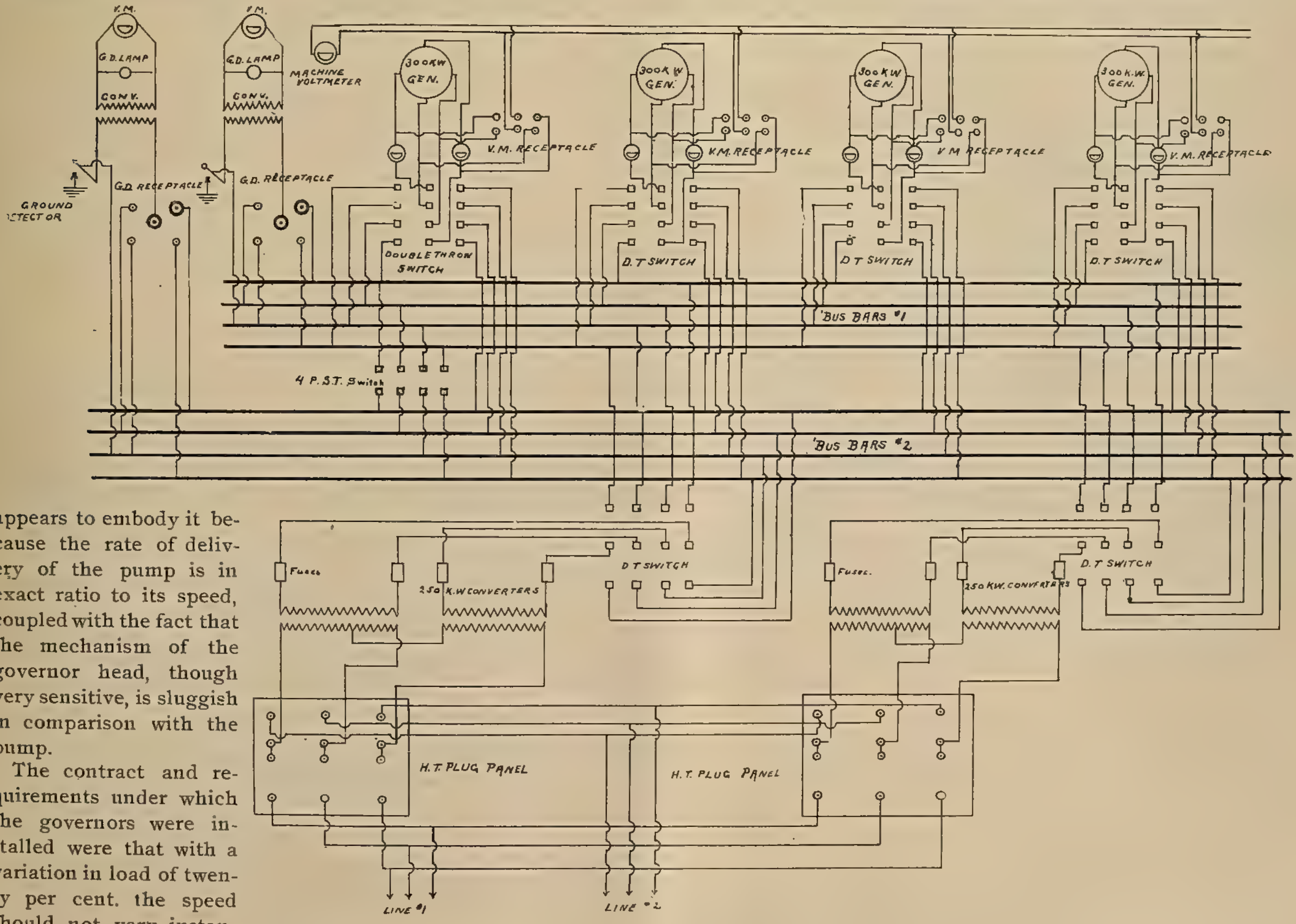
DRAWING TWO.

sulting in the lowering of the speed of the water wheel set, the valve *J* will drop proportionately, which will reduce the hydraulic pressure in the pipe *M* by affording a more free outlet, and the piston head *E* will descend by gravity, thus opening up more water on the wheels.

A more simple governing mechanism than that described would be hard to conceive, and it is very sensitive, in explanation of which the inventor states that it operates on a relaying principle quite as effectually as do the best of other governors of more familiar and more complicated form. Wherein the relaying exists may be hard to see, and perhaps some will dispute its presence at all, but certain it is that the hydraulic pressure from the pump is one that is delivered with mechanical precision according to the speed of the main shaft, and that the motion of the throttling valve *J* must, because of its intermediate method of actuation, lag behind any fluctuations that may occur in the hydraulic pressure by an interval of time. This situation expresses the principle which underlays all relay governors, and the Tutthill governor appears to embody it because the rate of delivery of the pump is in exact ratio to its speed, coupled with the fact that the mechanism of the governor head, though very sensitive, is sluggish in comparison with the pump.

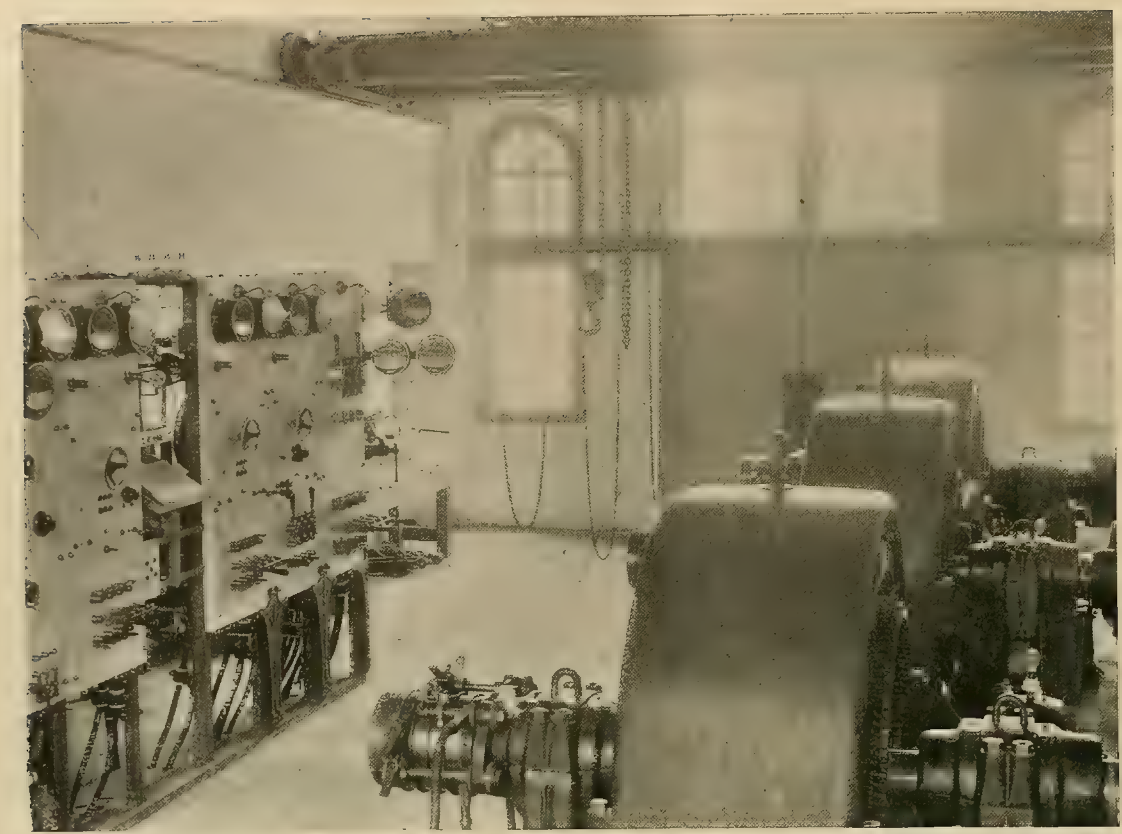
The contract and requirements under which the governors were installed were that with a variation in load of twenty per cent. the speed should not vary instantaneously more than three per cent. from normal. How closely the governors fulfilled this exaction is shown in the following extract from the letter of acceptance given by the San Gabriel Electric Company, and which gives the following as the result of the tests made of the Tutthill water wheel governors:

> Upon half load of 250 amperes upon one phase of the machine, the load having been dead load resistance, with a variation of twenty amperes, with speed of normal, 425 revolutions, the variation, as shown by the tachometer, was between four and five revolutions per minute.
>
> With the same load, throwing off fifty amperes, making twenty per cent. change, the variation was between seven and eight revolutions from the normal.
>
> Throwing the fifty amperes back on, making a variation of about twenty-five per cent., the variation of speed was practically the same as above.
>
> With the same load, 250 amperes, throwing off ninety amperes, which is a little more than 33⅓ per cent. change, the variation in the speed was fifteen revolutions above and five below, and the speed came back to normal without racing; throwing on ninety amperes, the variation in speed was practically the same.



GENERATOR, 'BUS BAR AND TRANSFORMER CIRCUITS.

DRAWING THREE.



INTERIOR OF THE SAN GABRIEL POWER HOUSE.

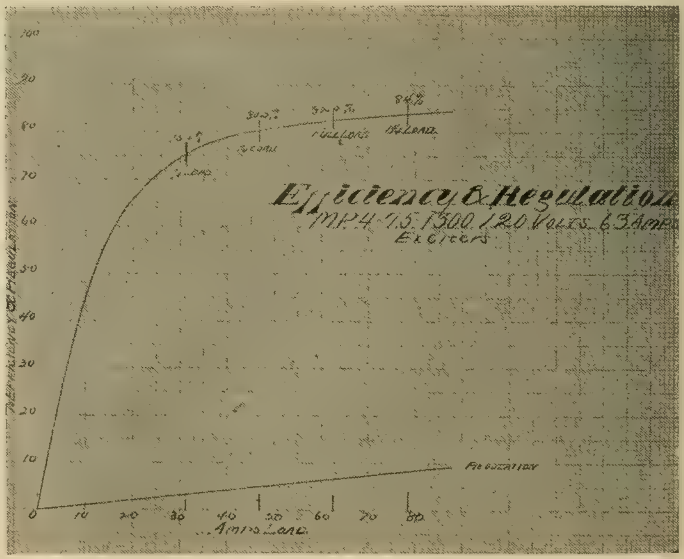
THE FOURTH GENERATOR IS NOT SHOWN HERE.

A flexible connection between each water wheel and generator is obtained by means of two discs placed close together in parallel planes on the abutting ends of the generator and wheel shafts. Each of these discs has four pins projecting and a pin of each disc is connected to the corresponding pin of the opposite disc by means of oblong links of leather. This is an improvement over the old coupling of this type in that it uses the leather edgewise without cutting, rather than wrapped around flat as formerly. All of the electrical equipment of the entire plant is of Westinghouse manufacture, and in the Azusa station are installed four generators, but three of which are shown in the interior view given on this page. These are of the revolving armature type with overhanging collector; their output is in two-phase current at an electromotive force of from 500 to 550 volts, and their normal speed is 450 revolutions per minute. They are erected on concrete foundations, capped by wooden frames, and in order to insure accuracy of alignment and to make slight changes more easy, a sheet of boiler plate, one-quarter of an inch thick was placed on top of each wooden frame. This obviates the old trouble in the erection of direct-connected machines from cutting into the wood while the alignment was being perfected. The bearings are of the usual self-oiling type with large oil reservoirs. The armatures are entirely bar wound and the coils are held in place with fiber wedges so that no band wires are required. As a result the armatures remain perfectly reliable under most trying treatment, as was exemplified by an incident which occurred in the shipment of one of them. Owing to the breaking down of the supports under one of the armatures in the box in which it was shipped, the armature rested on the bottom of the box for a considerable portion of its trip, during which the armature made at least three complete revolutions in the box, as was shown by the position of the oil cloth covering it. In spite of these revolutions and its long ride while resting on its surface, the armature was not injured in the least except for the paint and a few turns of the cord which bind down the tape at the end of the insulation. Half a day's work restored the armature to perfect condition.

GENERATORS, EXCITERS, WIRING.

The subject of directly connecting the exciters to water wheels versus belting to the generators, was taken up by the engineers and it was decided to belt the exciters to the generator couplings. For this a crown face was put on one side of the coupling and the exciters were belted directly from it. There was some objection to belting the exciters to the generators, as the variation in voltage was multiplied when a variation in speed occurred,* but, on the other hand, a fear that the small nozzles operating the water wheels that separately drive exciters at high head would become plugged by small objects that might come down the pipe line, led to the adoption of belt-driving the exciters from the generator shafts. Regardless of this however, the engineers of the company feel that the subject is still open for discussion. The exciters are of the four-pole type, having a capacity of seven and one-half kilowatts each, which is sufficient for two generators, and delivering 125 volts at 1300 revolutions per minute.

All of the station wiring is placed in subways made of redwood boards and painted with P. & B. paint on all sides. The wiring is done with rubber covered wire on porcelain knobs, and all work is open for inspection and changes as the subways are covered entirely with removable boards. This presents no difficulty, as the cement floor of the building is made flush with the tops of these boards and thus the even floor is not interrupted. The space back of the switchboards, which are placed five feet from the



THE EXCITER EFFICIENCY AND REGULATION CURVES.

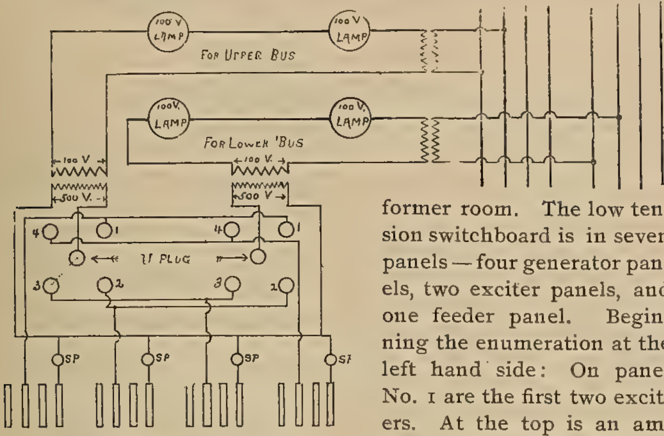
---

*See THE JOURNAL OF ELECTRICITY, volume VI, page 74.

wall, is made into a continuous subway, thus giving plenty of room for the wiring that necessarily becomes multiplied in the neighborhood of the switchboards. By leaving the entire space back of the switchboard for wiring and making the subway two feet deep at this point, it was found very easy to install all of the wires, and still keep them open and free for inspection.

THE STATION SWITCHBOARDS

There are two switchboards in the power house, viz.: the low tension board running along the center of the generator room, and the high tension board placed in the rear end of the transformer room. The low tension switchboard is in seven panels—four generator panels, two exciter panels, and one feeder panel. Beginning the enumeration at the left hand side: On panel No. 1 are the first two exciters. At the top is an ammeter for each of these exciters, below which is a Weston voltmeter which may be plugged from either exciter. Then follows a rheostat and a plug switch for each exciter as well as a set of three-pole, double-throw switches, by means of which either exciter may be thrown on to either set of exciter 'bus bars. There are five 'bus bars in the two sets, the sixth bar being dropped by reason of the use of one of the bars as common to both sets.



THE SYNCHRONIZING CONNECTIONS.

Drawing Two details the circuit connections of the two exciter panels, and it shows very clearly how any generator or group of generators may be excited from any exciter or combination of exciters. The rheostats in the circuit leading to the generator fields are placed near the wall in the space back of the switchboard and their leads are brought to the switchboard where they are connected to a face plate having handles extending to the front of the board. These rheostats consist of coils of iron ribbon, the turns of which are insulated from each other by mica, as is more commonly used in street railway practice. An interesting feature, and one which requires careful attention on the part of the switchboard attendant, must be noted in stations where exciters run in parallel and generators operate on two separate 'bus bars as is done at Azusa. To operate this combination so that it will be successful at all times, necessitates that the generator and its exciter shall be kept on the same set of 'bus bars. If this is not done, the exciter of one machine will run the exciter of a machine which is running on another set of 'bus bars, as a motor, by a sudden slowing down of the latter generator, thus overloading both exciters.

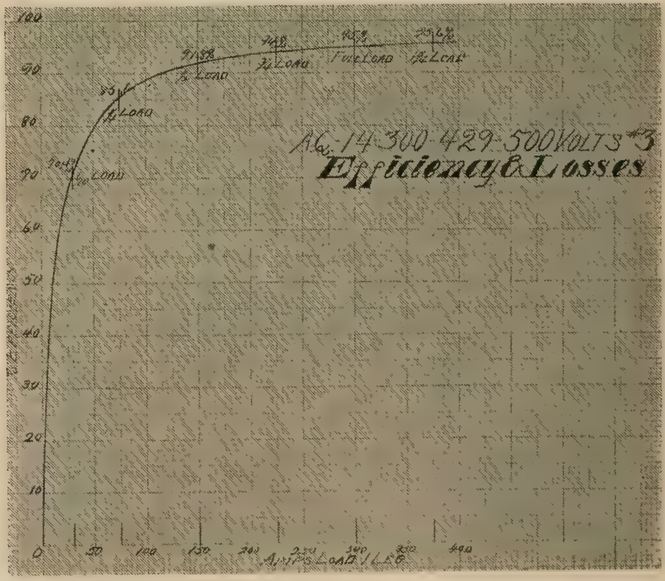
The next four panels in the low tension switchboard are for the respective generators, and each panel carries two 0 to 450 ampere ammeters—one for each phase; two synchronizing lamps, one field rheostat, one six-point voltmeter receptacle or plug switch, one four-pole, double-throw, two-phase generator switch, one five-point synchronizing switch, and a synchronizing plug. The connections of these devices are all shown in the upper portion of Drawing Three. There is but one plug for the voltmeter receptacles of the four panels, the use of which, with a common machine voltmeter, obviates any possibility of short circuit in plugging in an instrument. The generators are on the centers of the two-phase, double-throw switches, the manipulation of which will, therefore, throw the generator on either set of 'bus bars. In addition, the two sets of 'bus bars may be thrown in parallel by means of the four-pole, single-throw switch indicated, this 'bus bar multiple switch being installed on the back of the main board.

Panel 7 is the transformer or feeder panel, carrying two four-pole, double-throw switches by means of which either set of raising transformers may be thrown on either set of 'bus bars. The transformer primaries are on the centers of these switches and each of the primaries is fused. In addition, the feeder panel carries the 'bus bar voltmeters and the ground station detector receptacles, lamps and plugs shown in the upper left hand corner of Drawing Three. These two voltmeters and the machine voltmeter are the three instruments appearing on the swinging arms at the end of the switchboard.

Each generator can be synchronized with either set of 'bus bars. Incandescent lamps are used as synchronizers, the switches being closed when the lamps are at full candle power.

The high tension switchboard, located in the rear of the transformer room as stated, is of the receptacle and flexible plug type. The flexible plugs are operated with bayonet handles, which can be inserted in the plugs with a half turn, and a single pair of handles are used to operate the whole board. It is stated that these plug switches will easily open any short circuit on 15,000 volts, or any inductive load, as it is only necessary in case of heavy arcing to remove the plugs to a greater distance. How these switches are connected to the transformers and lines is shown at the bottom of Drawing Three. With the transformer leads terminating at the switch centers, and with the lines connected to the upper and lower receptacles, the throwing of either set of raising transformers, either singly or in multiple, on either line becomes a simple matter. A method for coupling the lines in parallel is also provided by the use of flexible plugs on the double set of receptacles connected with the transformer leads along the center of the high tension plug panels, or the lines may be thrown in multiple direct by connecting the upper and lower rows of receptacles of a panel with flexible plugs.

The process of synchronizing alternators is one of determining the phase position of two machines that are to be coupled in multiple arc, so that when these phase positions are identical, or technically, "in synchronism," the paralleling switch may be thrown on the instant. The comparison of the value of two forces, each existing for a period of but one-fiftieth of a second, and the ability to determine the exact interval of time when these constantly varying forces coincide at every point or sphere of their brief existence, is a process as beautiful as it is wonderful to the layman. Several different methods of synchronizing polyphase generators have been described in previous issues of THE JOURNAL OF ELECTRICITY,* but the method now to be described embodies some in-



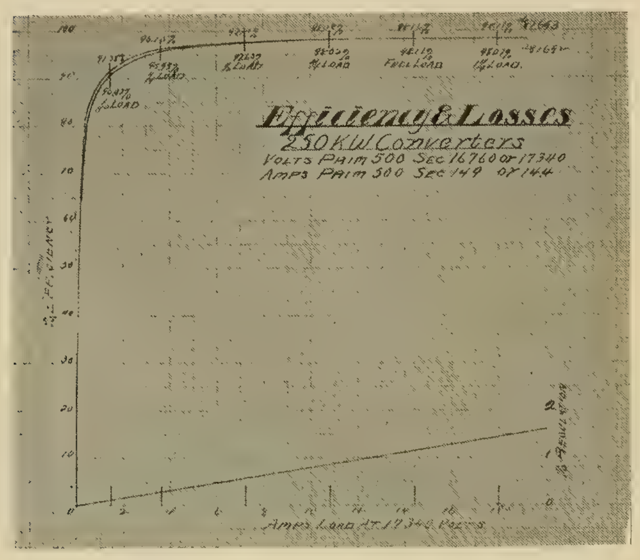
THE GENERATOR EFFICIENCY CURVE.

---

*Synchronizing Three-Phasers, Volume IV, page 7; Synchronizing Two-Phasers, Volume V, pages 20, 21, 70 and 71.

SYNCHRONIZING.

novations. A valuable feature of the synchronizing system used in the San Gabriel transmission rests in the fact that it may be extended for any number of generators without further installation of transformers than is required for paralleling two alternators. The diagram on page 93 gives the circuits for the synchronizing system used in both the power house and the sub-station of the San Gabriel Electric Company, in which the distinguishing characteristic, so far as the operator is concerned, is the use of a single U-plug and a single synchronizing plug. In the drawing, the four generators are represented at the bottom by the four sets of collector rings, from one of which a connection is carried through a synchronizing plug to a common 'bus wire, and from another of which (the other side of the same phase) a connection is carried to the plug receptacle whose number corresponds to the number of the generator to be synchronized. Alternate collector rings are phases on Westinghouse two-phasers, hence in the diagram rings two and four give the sides of, say, the leading phase. Each group of plug receptacles consists of as many receptacles as there are generators, plus one central receptacle, and the number of receptacle groups need not exceed one for each set of main 'bus bars. Even the two groups may be reduced to a single group by connecting the terminals of a transformer to a double-pole, double-throw switch so that it may be thrown on either of the two sets of 'bus bars as desired.

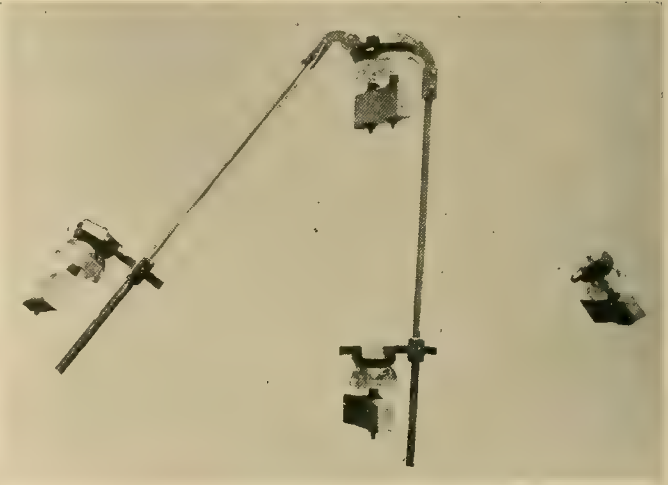


EFFICIENCY AND REGULATION CURVES OF THE 250-K. W. CONVERTERS.

Two transformers, each having a 500-volt primary and a 100-volt secondary, have their secondaries connected in series, in which is also a series of two 100-volt incandescent lamps. The primary of one of these transformers is connected across one phase of one of the 'bus bars — the upper 'bus for instance — while the primaries of the other transformer are connected to the 'bus wire above referred to, and to the central plug receptacle, respectively. The generators are phased only with 'bus bars, and not with other generators, unless a single generator happens to be on the 'bus bar with which the first generator is to be synchronized, and as one of the primaries is always across one phase of a 'bus bar set, it is only necessary to throw the other primary across the proper phase of the generator to be synchronized. This is a process requiring two movements: first, the insertion of the synchronizing plug *S P* in the receptacle of the proper generator, (there is only one such plug receptacle on each generator panel) and, second, the insertion of the U-plug connecting the center receptacle with the receptacle corresponding to the generator to be synchronized. If, for instance, the third generator is to be synchronized with the upper 'bus bar, insert the synchronizing plug *S P* in the receptacle shown at the third set of collector rings in the diagram, which is equivalent to closing a single-pole switch; then, by means of the U-plug bridge the center receptacle of the group with receptacle No. 3, as shown by the dotted line in the drawing. The primary of the lower 500- to 100-volt transformer is now across the leading phase of generator No. 3, and a potential of 100 volts will appear on its secondary. In series with this secondary, however, is the secondary of the other transformer receiving energy from the upper 'bus. Obviously, then, if these secondaries are so energized by their primary windings that their potentials oppose each other, the opposing potentials, if equal, will be neutralized and no current will flow. Any difference in potential between the secondaries will, however, create a current flow that will be in direct proportion to the algebraic sum of the two potentials; therefore, if at a given interval of time, the 'bus bar transformer has a positive potential of ninety volts, and the other transformer has a negative potential of seventy volts, the electromotive force applied to the terminals of the two lamps in series in the circuit will be twenty volts.

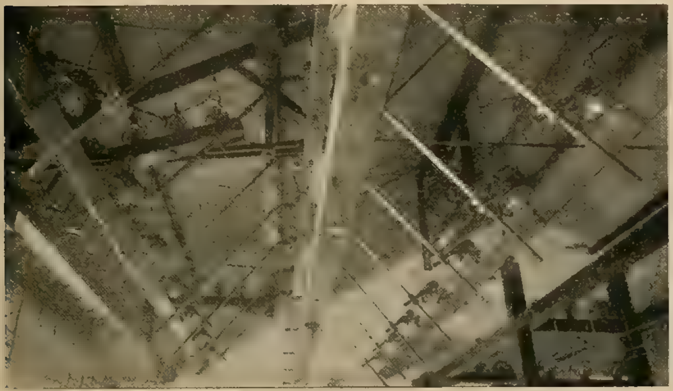
UNASSEMBLED PARTS OF HIGH TENSION SWITCH.

We are dealing now with two separate sources of electric potential, each of which start from zero, then rise to a positive potential of 100 volts, next drop back to zero, and on down to a negative potential of 100 volts, and then back again to zero, completing fifty such cycles per second, or 6000 per minute. However exact the mechanical arts may be, it is impossible to operate two generators so that they will be mechanically and electrically independent, yet put out no more or no less than 6000 alternation pers minute; they will vary several hundred alternations above or below the normal rate each minute, and as these variations occur they will be reflected with the utmost precision in the voltage appearing at the terminals of the two lamps wired in series with the transformer secondaries. The lamps are out at times, then they will redden and dim, then burn up brighter and dim, then perhaps they will slowly rise to full candle power, staying there for a second or two, and precisely at this instant the machine switch must



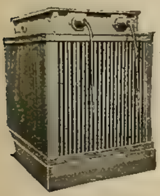
HIGH TENSION SWITCH AS ERECTED.

be thrown in connecting the generator to the 'bus bar, for the generators are in synchronism. A moment's delay will necessitate waiting for the cycle of full candle power to come around again, albeit the potentials will pull themselves in step even though the generators be out of phase at the time the switch is thrown. It is an inherent characteristic of polyphase machinery that it will synchronize regardless of the interval of switching-in, but synchronizing when the machines are out of phase imposes strains of mechanical and electrical natures that are always to be avoided. The paralleling of the two-phase equipments of the San Gabriel transmission is a process that is as reliable and satisfactory as is the paralleling of two direct current generators, despite the fact that water-driven generators are synchronized with a steam-driven one; or that rotaries or the railroad circuit are synchronized with each other or with either one or any combination of the preceding.



THE HIGH TENSION SWITCHES.

All station transformers used by the San Gabriel Electric Company are of the self-cooling, or oil-insulated, air-cooled type, and, except that different numbers of leads are taken out from the different styles of transformers as they may be adapted for rendering various characters of service, they are similar in form to that illustrated in the subjoined miniature cut. The transmission proper is on the Scott system,* that is, two-phase generation, three-phase transmission, and two-phase distribution. The four 250-kilowatt raising transformers at Azusa are, therefore, two-phase three-phase transformers, and the lowering transformers at Los Angeles are three-phase two phase transformers, but the last named deliver variable electromotive forces as required, while the former are wound at a fixed ratio, approximately taking 500 volts and delivering 16,500 volts to line. In these transformers both primary and secondary are divided up into several flat coils, wound with many layers and few turns per layer, each coil being insulated separately, and it is claimed that the advantages of this construction are that it divides the total electromotive force between several coils, reducing proportionately the strain within an individual coil; that it divides the electromotive force in a single coil between many layers, thus reducing the potential between adjacent layers; that it enables the coils to be spread apart at the ends, so that a very large surface is exposed to the oil, thus providing ample radiating facilities and most thoroughly insulating the bent part of the coils; that the regulation of the transformer is greatly improved thereby; that the windings may, with great facility, be connected in series or multiple, giving a wide range in electromotive force; and that in case of damage to a coil, another one may be substituted with little trouble and without returning the converter to the factory. In this type of transformer, the core and coils are placed in iron boxes composed of two parts; an inner portion made of heavy sheet iron for containing the oil, and an outer framework of angle iron for supporting and holding the inner case. The surface of the inner case is broken up into a number of corrugations or flutes, so that the surface exposed to the air is greatly increased and capable of dissipating into the air the heat generated in the transformer; the oil acting as a conductor for transferring the heat from the transformer to the case. The transformers are set on wooden frames, each of which is independent of the others and can easily be removed, and they are arranged so that should it become necessary to remove a transformer from the case, it can be placed on rollers and rolled out into the generator room under the crane.



The low tension leads, after passing through the subway from the feeder switchboard, rise on the inner surface of the wall between the generator room and the transformer room. Here the primary fuses are installed on separate marble slabs and the leads go through the walls to the transformers.

ARRESTERS.

From the transformers, the high tension leads are carried overhead on line insulators to the high tension switchboards, choke coils and lightning arresters. The former are of the flexible plug type as previously described, and the choke coils and arresters are of the so-called "pyramidal form," owing to their arrangement in the form of an inverted pyramid as seen in Figure 1. In this diagram, each circle represents a choke coil; each rectangle represents one unit type "C" non-arcing metal lightning arrester, and the grouping is such that there are six choke coils in series with seven 2000-volt arresters between each line and ground. Figure 2 shows how this is done by the use of eighteen arresters, as at Azusa. The arresters are placed on a platform overhead in the transformer room and thus far they have worked quietly and required no attention.

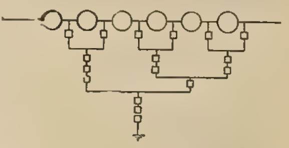


FIGURE 1.

THE LINE.

Full details concerning the line are presented in the table of engineering data appended hereto, but the noteworthy features of it are that it is in two three-phase circuits, each consisting of three No. 5, hard drawn copper wires, supported on 5½-inch Locke glass insulators which are mounted on locust pins boiled in paraffine and then driven into cross arms previously painted with P. & B. paint. Each set of lines is spiralled — one-third turn at 7¾ miles from the Azusa end, and one-third turn at 7¾ miles from the sub-station. The two lines are spiralled in opposite directions. The line is twenty-three miles in length, the poles are round and placed about 125 feet apart. The six wires are mounted on two cross arms, four wires being on the lower arm and two on the upper, the three wires of each circuit being placed at the corners of an equilateral triangle having thirty-inch sides.

The effects of spiralling were illustrated in an interesting way during the starting up of the plant. One line was, at that time, installed without spirals, and the other was installed with two one-third spirals. There seemed to be no effect from mutual induction, but the telephone line objected to this arrangement. The telephone was quiet when the current was carried on the line having the two spirals, but when the straight line carried the current, it was impossible to use the telephone. It was therefore decided to put two spirals in the straight line at the same points as the other spirals, but in the opposite direction. This was done and the telephone seemed to be satisfied. There is no noise whatever on the telephone line and the instruments and lines can be used and are used in long distance work by the Sunset company with great satisfaction.

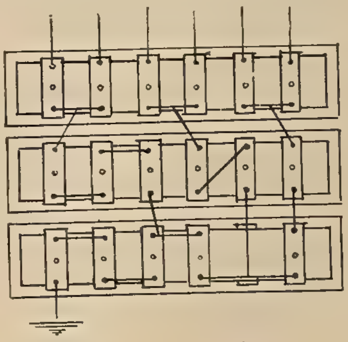
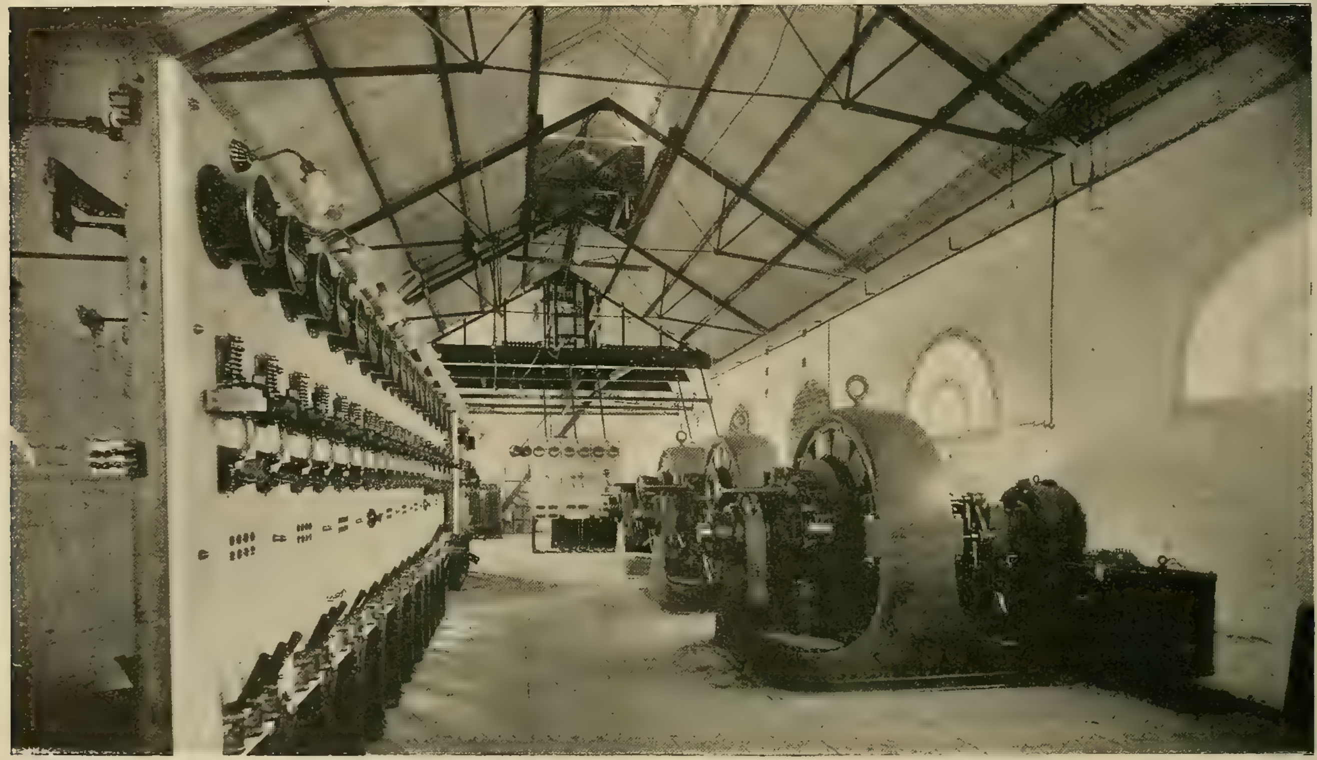


FIGURE 2.

---

*Volume V, page 130.

The telephone line is transposed every fifth pole and the wires are placed one above the other on the same side of the pole. The engineers of the plant hold that this arrangement has an advantage over placing the wires on two sides of the pole on a short cross arm or bracket. The telephone line is of iron wire, No. 12, and is so satisfactory that it will probably result in the discontinuance of the installation of copper telephone circuits hereafter on transmission plants of moderate length.



ROTARIES AT THE RIGHT, TRANSFORMERS IN THE REAR.

LOS ANGELES SUB-STATION OF THE SAN GABRIEL ELECTRIC COMPANY.

The sub-station, situated on the east side of Los Angeles street near Third street, is a brick structure with steel roof trusses, corrugated iron roofing and concrete floors. The transmission lines enter from the rear and are at once carried into the arresters and choke coils, whence they continue to the high tension switches illustrated on page 95. The arrester equipment is identical with that at the power house. The sub-station is a one story structure, but the high tension and transformer portion is of two stories, and about seven or eight feet above its floor are the high tension fuses and switches in detail and as assembled, on pages 94 and 95. These switches, which are known as the M.-T. high tension switch, are mounted on line insulators and are composed of a long wooden jaw upon which is mounted the high tension fuse and the switch contacts. The upper end of the switch jaw is mounted with a removable socket on a pair of high tension insulators; the lower end of the switch jaw swings into a clip terminal mounted on another insulator and when the switch is closed it is in a position about forty-five degrees from the horizontal. When the switch is opened it is only necessary to pull or strike this handle with a special grounded switching stick and the switch jaw falls to a vertical position where it is caught in a bumper clip mounted on a third glass insulator. The upper or pivot end of the switch is connected to the transformer so that when three switches are open, the jaws are dead. By a simple lifting movement the jaw is unhooked at the top and if a fuse has blown it can be replaced, or an extra jaw, of which several are supplied, can be put in its place. A high tension fuse, or a set of three high tension fuses can be renewed in about one minute, and this can be done without any danger to the station attendant.

HIGH TENSION SWITCHES.

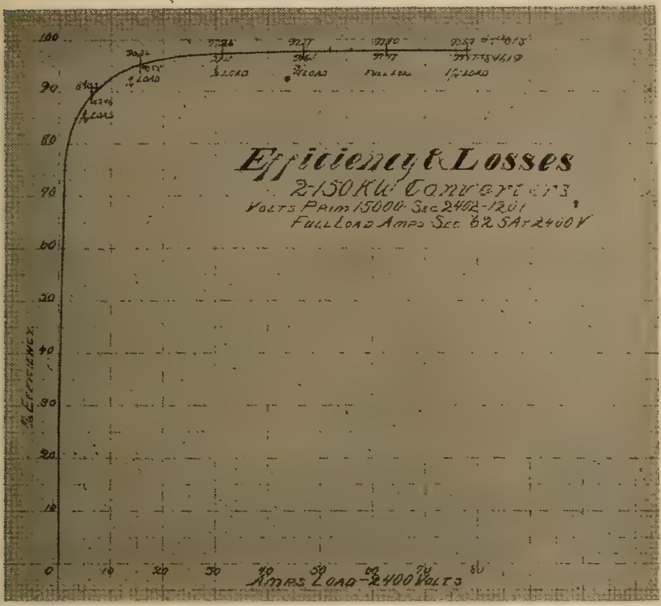
These switches are erected in sets of three; each double switch is connected at the pivot end to the transformer. The lower end of the jaw on one side connects to line *A* and on the other side to line *B*; thus each set of switches is a paralleling switch for the main line, and a circuit can be changed from one line to the other, if the lines are in parallel at the generating end, without disconnecting or interrupting the service.

The fuses, which are thirty inches long, are mounted in soft rubber tubes. If the fuse blows, the current of air in the tube blows out the arc, and the falling of the rubber tube to the floor insures the breaking of the arc and at the same time marks the place where the fuse has blown. The station attendant is therefore not troubled in finding where the fuse has blown, and while there are no less than eighteen two-way switches, the operation of these is very simple. This switch is very cheap and will probably come into general use in its present or modified form.

The lightning arresters are of the same type as those at the generating station.

The transformers are set in pairs in the room immediately under the high tension room, and each pair reduces the three-phase line current at 15,000 volts to two-phase current of the voltage required for its particular service. Each transformer is set on a separate wooden base and the floor is arranged with sub-ways so that all of the low tension wiring is below the floor. The large "I" beams of the high tension room floor are of sufficient width and size so that a timber which is cut in between the webs of these can be used as a support when lifting a transformer out of the case. The high tension wires of the transformer to be lifted out are, of course, dead during this operation, and the wires leading to the room above are so arranged that the men need not be injured by proximity of high tension wires, if ordinary care is taken. The low tension wiring is done here, as at the generating station, with rubber covered wire on porcelain knobs. Each pair of transformers, or system of transformers, is equipped with spark gap protectors tapped in at the center of its low tension side, and thus static sparks from the main line are kept from interfering with the convenience and comfort of customers.

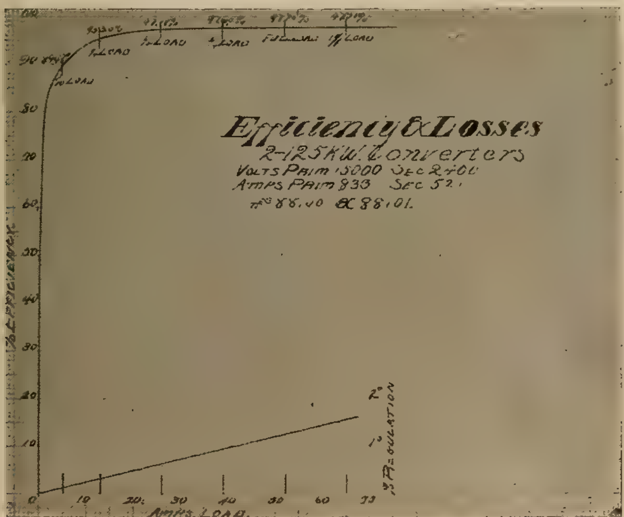
The various characters of service rendered by the San Gabriel company made it advisable that the lowering transformers should deliver radically different electromotive forces having nominal values that are but approximations. Thus, the two 150-kilowatt transformers supplying the 500-direct-volt rotary are wound for the secondary delivery of either 370, 400, 440 or 460 volts. Then there are four 125-kilowatt transformers delivering, nominally, 218 volts; four 150-kilowatt transformers delivering 2400 volts, besides the two 125-kilowatt lowering transformers delivering a very wide range of electromotive forces to the regulating dials and reverse switches, and the series transformers whose primaries take current from the regulators just mentioned and whose secondaries are cut into the four legs of the two-phase circuits leading to the 250-direct-current-volt rotaries. The above, together with two 250-kilowatt transformers delivering 218 volts which are now being installed, constitute the transformer equipment of the sub-station.



EFFICIENCY CURVE FOR THE TWO 150-KILOWATT CONVERTERS.

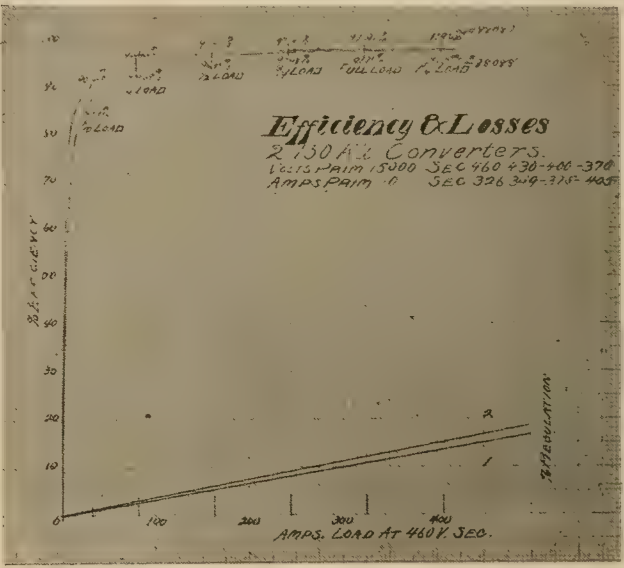
THE DISTRIBUTION.

The sub-station was installed so as to enable the operation of four varieties of electric service, viz.; (1) a single-phase 2400-volt lighting system for residence and outlying districts; (2) a 2400-volt two-phase power service for synchronous and induction motors; (3) a 500-volt direct-current power service for direct-current motors, elevators, etc., and (4) a 220-volt direct-current three-wire service for incandescent and constant potential arc lighting on either the 110- or 220-volt system. The 2400-volt single-phase lighting circuits are, of course, merely one side or the other of the two-phase 2400-volt power system, as the delivery of both incandescent lighting and power from the same transformers are not attended with difficulty. The 500-volt power service was made necessary by the large number of 500-volt direct-current motors in use in Los Angeles prior to the installation of the San Gabriel plant, and the 220-volt three-wire system was preferred by the San Gabriel company's engineers to a low tension alternate-current distribution because direct currents enable a more satisfactory operation of constant potential arc lamps, and, above all, their power factor is at all times 100 per cent., while against them can only be charged the fact that the efficiency of the rotary converter is slightly lower than the efficiency of the stationary transformers.



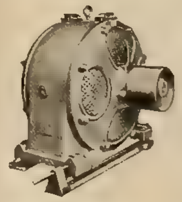
CURVES FOR CONVERTERS DELIVERING 2400-VOLT, TWO-PHASE CURRENT.

The operation of the 2400-volt lighting circuit requires no specific reference beyond the fact that the single-phase current is distributed through Stilwell regulators giving a range of from 2200 to 2400 volts.



CURVES FOR TRANSFORMERS OPERATING THE 500-VOLT ROTARY.

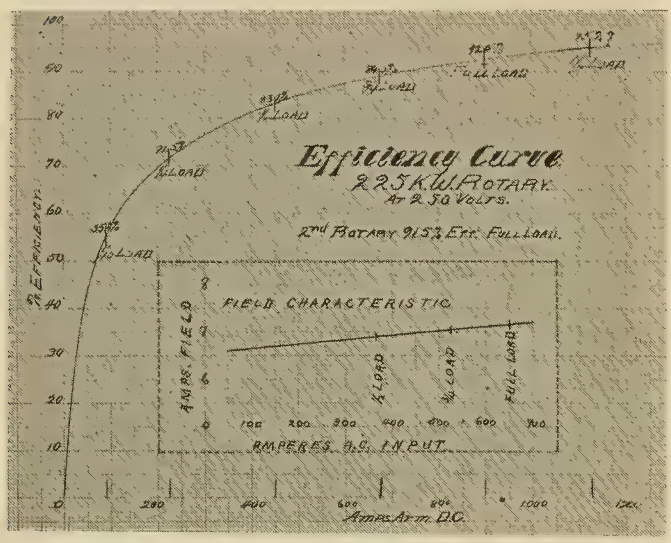
On the two-phase power circuit are several large type "C" induction motors, here illustrated, and among the larger consumers are the Globe Mills, of the McDonald Feed and Milling Company, which is operating a 100 horse-power motor and a 40 horse-power motor directly from the 2400-volt lines at a distance of one mile from the sub-station. The City Brick Company, three miles away, is operating a 40 horse-power motor with transformers at 400 volts. The Bradley Fertilizing Company, six miles distant in another direction, is operating 75 horse-power—a 50 horse-power, 20 horse-power and 7 ½ horse-power motors. The Globe Mills are new mills which have been worked to a capacity of 266 barrels per day, although they were guaranteed for but 200 barrels, and as the mill works close to the higher rate, the starting of them by an induction motor was considered as presenting great difficulties, since it was necessary to start at full load of the 100 horse-power motor, and the starting torque is said to be once and a half times full load torque. The machinery is divided into two portions, part being operated by the 40 horse-power motor and the remainder by the 100 horse-power motor, and the writer can bear witness to the fact that these motors take up their given loads with surprising ease and celerity.



Before proceeding to the direct-current distributions, and as the use of rotary converters is not common in California transmissions (although many will be in operation before the close of the com-

ON ROTARY CONVERTERS.

ing year), a brief reference to their principles of operation may be of interest. A rotary converter transforms alternating to direct current, or *vice versa*, by reason of its process of rotation as a synchronous motor. It is simply a commutating machine which makes alternating and direct currents interchangeable, just as primary and secondary potentials become interchangeable in ordinary transformer work. Its mechanical design and construction is similar to direct-current multipolar generators. The field poles of the rotaries in the San Gabriel plant are laminated and rigidly held by a circular frame of cast iron; the armature, or revolving element, is of the iron clad type with core built up of thin steel plates of the best magnetic quality and containing bar copper windings; the commutator and winding are practically identical with those of a direct-current generator of equal capacity, but the shaft carries, in addition to the commutator, four collector rings similar to those used on a two-phase generator. The armature winding is tapped so that the terminals of the two sets of two-phase leads are taken from points on the winding 90 degrees apart, and these leads go to their respective collector rings. Two-phase current is applied to the collector rings and the machine run as a synchronous motor from which direct current may be taken through brushes and the commutator; or, to reverse the operation, as has been frequently done in the San Gabriel plant, direct-current may be applied to the commutator, when the machine will run as a direct-current motor and deliver two-phase alternating-current at the collector rings.



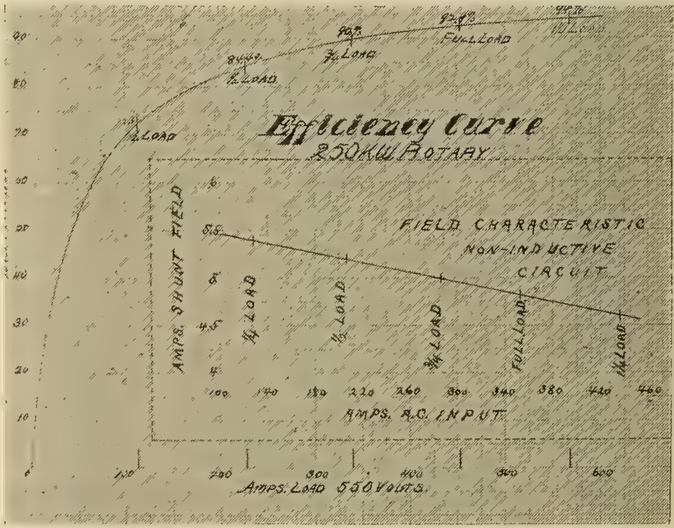
EFFICIENCY AND EXCITATION CURVES OF TWO 225-KILOWATT ROTARIES.

One marked difference exists between the rotary converter or transformer and the ordinary alternating-current transformer. In the latter, the relation between the primary and secondary potentials is fixed by the ratio existing between their respective windings; in the rotary transformer the potential of the direct-current side, be it delivered or impressed, is invariably higher than the potential of the alternating side for the reason that while the crest of the potential wave in alternating current work coincides in value with the electromotive force obtainable from the same machine when used as a direct current generator, the effective value of the alternating potential wave is its mean effective voltage—not its maximum or crest voltage. Other conditions, such as form of wave and the number of phases, exert further influences upon the relation existing between the voltages at the alternating and direct current sides of a rotary converter; but this relation, if the generator be given a true sine wave, will be about seven-tenths times the corresponding continuous-current voltage in a two-phase rotary, and about six-tenths times the corresponding direct-current voltage in a three-phase rotary.

In no case, therefore, can the ratio of transformation in a rotary converter be arbitrarily fixed as is so readily done with alternating-current transformers. It is impossible to wind a rotary transformer in a ratio of, for instance, 10 to 1, so that a potential of 2400 volts may be applied to the collector rings and 240 volts in direct-current will be available from the commutator. To get 240 volts direct-current, an alternating potential of 173 volts in two-phase current must be delivered to the collector rings of the San Gabriel rotaries, hence step-down transformers must be installed to reduce the line potential of approximately 15,000 volts to the 173 volts required to produce 240 volts at the direct-current end. As step-down transformers may be readily arranged to deliver a variable voltage through different terminals, the delivery of different direct-current voltages from the rotary becomes only a matter of connecting the proper set of transformer terminals to the collector rings. Secondary regulation is effected by the potential regulator, to be more fully described hereinafter.

DIRECT CURRENT SERVICE.

Returning to the direct-current distributions, the 500-volt power circuit is taken from a 250-kilowatt compound wound rotary which is supplied with two-phase current, at nominally 380 volts, from two 150-kilowatt transformers. Four secondary leads, of 270, 400, 440 and 460 volts respectively, are brought out of these transformers so that any necessary voltage may be obtained on the direct current side of the rotary. Direct-current is taken off by twelve sets of carbon brushes, with two brushes on the arm of each set; the brush holders are of the swivel type; the armatures are bar wound; the cores have cooling air ducts, and there are four collector rings on the alternating-current end, while overhanging as an extension of the main shaft is a 10 horse-power induction starting motor. Starting from the alternating current end is, therefore, a process of driving the rotary as a direct-current generator by the starting motor and thereby exciting the fields, which, in the 225-kilowatt rotaries, are simply shunt wound. When the rotary is up to synchronism, the two-phase current may be thrown on and the rotary will always be of right polarity. This is a marked advantage over rotaries that are self-starting from the alternating-current end. While the San Gabriel rotaries may be started from either side, they are ordinarily started on the direct-current side, that is, one from the other by means of a water rheostat, in fact, a start can be made from the direct-current side of any rotary with much less fluctuation than from the alternating-current end, since the starting current can be applied very slowly, giving the governors at the power station ample time to act.



EFFICIENCY AND EXCITATION CURVES OF THE 250-KILOWATT ROTARY.

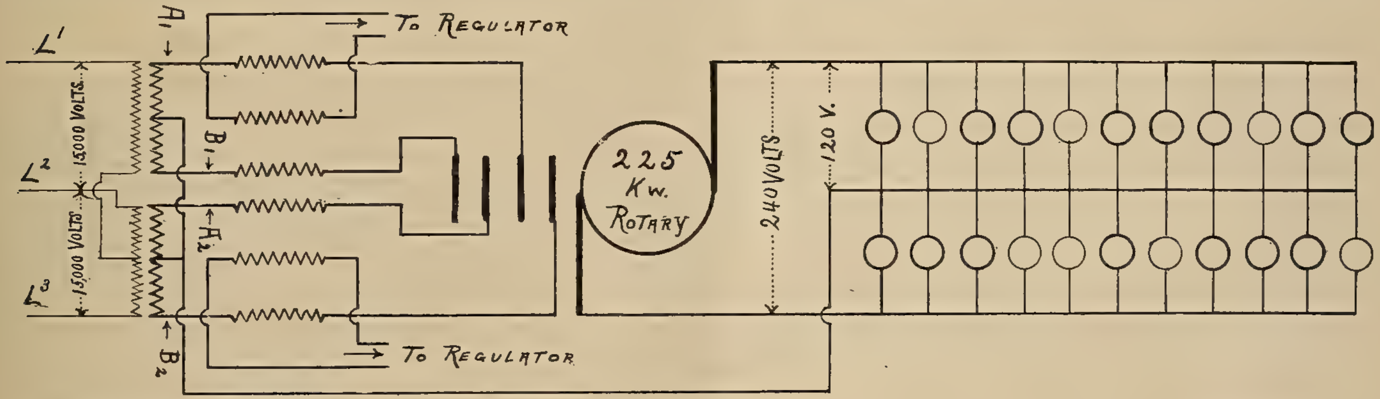
All incandescent lighting is delivered from these rotaries on the Lamme system of electrical distrbiution*, which is the equivalent of the Edison three-wire system in that the circuits are of three conductors — a positive, a negative and a neutral. The rotaries deliver from 220 to 240 volts in direct-current to the outside wires of the three-wire system according to the load, while the neutral is carried back to the reducing transformers where it taps in to the middle point of the secondaries of the two-phase transformers from which the rotary is operated. This is shown in simplified form in Drawing Four, and it is interesting to note that while in regular practice the neutral is tapped in to the secondary of each transformer, the system will operate almost equally well should either one of these connections be dropped.

---

* United States Letters Patent. 607,621 issued July 19, 1898.

REGULATION.

The regulation of this three-wire service is effected in the manner shown in Drawing Four, wherein the two secondaries of a series transformer are introduced into the respective sides of each of the two-phase circuits operating the rotary. The four wires constituting the two-phase circuit are lettered A_1 B_1 A_2 B_2 respectively, and each includes one of the two secondaries of the two series transformers shown, the primaries thereof being supplied at various electromotive forces by two regulating dials that commutate loops from the secondary windings of two 125-kilowatt lowering transformers. The dial points are in circular form and the collecting arm is actuated by a hand lever through a ratchet motion. By giving this hand lever a quarter twist the direction of motion of the arm is reversed. When the arm comes to the end of its travel, giving no electromotive force to the series transformers, an automatic interlocking device releases the reversing switch which allows the action of the regulator to be made to raise or lower the electromotive forces of the rotary. The range of the regulating dial is from 220 to 320 volts on the direct-current side, while without the regulators the rotary delivers about 270 volts, giving a range of 50 volts above and below normal. This is obtained in 68 points of less than 2 volts each.



SIMPLIFIED DIAGRAM OF THE DIRECT CURRENT DISTRIBUTION.

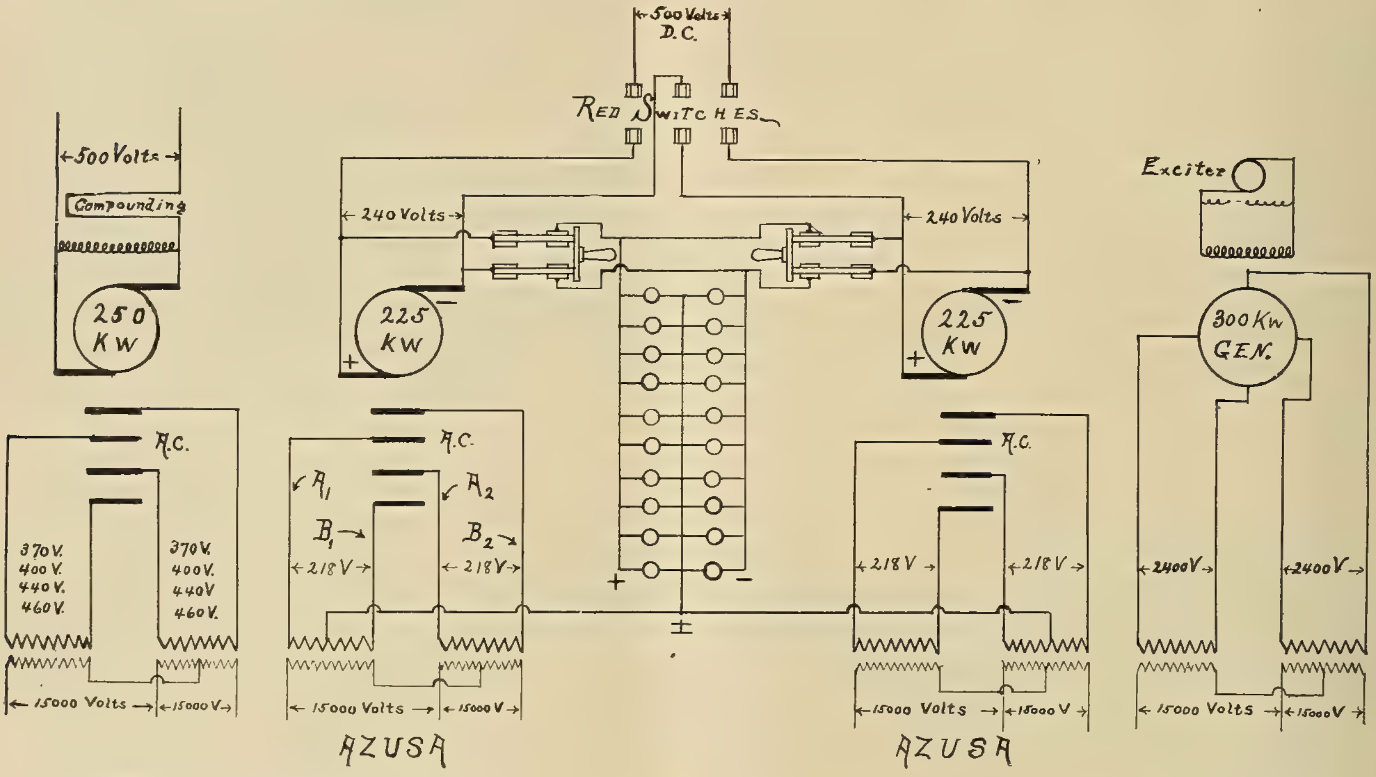
DRAWING FOUR.

The auxiliary plant, which adjoins the sub-station, consists of 500 horse-power in water tube boilers burning oil, a 500 horse-power Corliss non-condensing engine and a 300-kilowatt, 2400-volt, two-phase generator driven therefrom by independent ropes. The exciter is mounted on a bed plate directly connected with the generator frame and is belt driven from the end of the generator shaft. This generator, during periods of low water, operates the 2400-volt circuit previously referred to and also supplies its surplus current to the two-phase sides of the four 150-kilowatt lowering transformers, which then deliver three-phase current to the line at an electromotive force of about 15,000 volts, thus working in parallel with the power house at Azusa.

The combinations existing in the sub-station are presented in simplified form in Drawing Five, the fundamental feature of which is the fact that every variety of service delivered may be transformed from the line potential, or, conversely, either the steam-driven generator or the 500-volt rotary (if driven from the direct-current side) may deliver three-phase current to the line, thereby assisting the Azusa plant or operating the entire service should the transmission be disabled. During the peak of the load the 500-volt rotary has been so operated from the Los Angeles Railway plant, which in addition has also carried the 500-volt power circuit of the San Gabriel company, and this expedient has enabled the San Gabriel company to maintain uninterrupted service during the dryest summer that California has ever known.

No better way exists of conveying an understanding of the different combinations under which the electrical equipments of the plant have been worked during the trying season of drought just passed than by recalling the fact that the system may be resolved into five distinct portions, viz: (1) The Azusa station; (2) the Los Angeles auxiliary plant; (3) the practically unlimited power at 500 volts from the plant of the Los Angeles Railway Company; (4) the 500-volt rotary, and (5) the 250-volt rotaries. From the three first named sources of power, the four different characters of service heretofore enumerated must be rendered. Last summer the Azusa plant was capable of delivering but about one-third of its capacity to the line, and when it is known that within a month after the plant was started it was called upon to carry a greater load than was believed it would be possible to secure within six months, it will be seen that it was necessary to take heroic action to meet the exigencies thrown upon the plant by reason of the shortage of water and the unlooked for increase in business. The auxiliary plant was therefore installed early in the summer in the belief that it would carry the 2400-volt service, and that the Azusa plant could, with the assistance that it would receive from the auxiliary plant, carry the direct current lighting and power loads. It soon transpired, however, that these two plants were unable to carry the load, being short 250 kilowatts, practically all of which would have to be delivered to the three-wire mains at 220 volts. The only available source of power from which this 250 kilowatts or more of energy could be drawn was from the Los Angeles railway plant and the reinforcing of the transmission line thereby through the operation of the 500-volt rotary from the direct current side.

As might be presumed, the varying character of the load, as the novel nature of the installation, brought about many interesting and instructive combinations, among which may be enumerated the following, each of which has been made and tested under actual working conditions in commercial service. At all times the four classes of service have been delivered without interruption: First is the ordinary combination of running the entire plant from Azusa, in which the generators, as well as the 250-volt rotaries were run either singly or in multiple; second was the running of the entire system from the steam plant; third, the running of the entire system from the railway plant through the 500-volt rotary; fourth, the operation of any or all of these sources of power either singly or in multiple; fifth, the running of the 225-kilowatt rotaries in multiple from the alternating current side, and in series on direct-current sides, in which event one rotary delivers 220-volt service, and the two being in series operate the 500-volt power circuit; and sixth, the operation of the two 225-kilowatt rotaries in series from the railway plant, one rotary operating one-half the three-wire system direct at 220 volts and the other rotary operating at 220 volts in series with the other half of the three-wire load. This last combination is the most remarkable because of the first rotary, operating one-half of the three-wire load direct at 220 volts, is driven by the alternating-current output of the rotary which has 280 volts on the direct current side. The auxiliary plant has also run in multiple with the two 225-kilowatt rotaries in series. As to the two 225-kilowatt rotaries, one has been run as a single-phase rotary, furnishing 220 volts and 70 per cent. of the total capacity of the machine. These two rotaries have been run in multiple, using one as a two-phase and the other as a single-phase machine, and in no instance has the polarity been reversed.



SIMPLIFIED DIAGRAM OF THE LOS ANGELES STATION CONNECTIONS.

DRAWING FIVE.

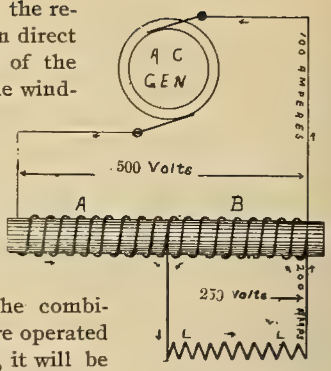


FIGURE 3.

SOME INTERESTING COMBINATIONS.

The means by which these combinations and others may be effected will be seen from Drawings Five and Six, but the running of the rotaries in series from the direct-current ends and the operating of the three-wire service therefrom presents features of such unusual interest that a more extended reference is deemed advisable. Assume that, as in Figure 3, an alternator is delivering 100 amperes at 500 volts to the load as shown. If this coil is in two equal sections, *A B*, the electromotive force across the terminals of each will be 250 volts, and if the terminals of section *B* are connected through the load *L L*, a current of 200 amperes at 250 volts will be found in the circuit so formed. How is it then, that a current of 200 amperes may be shunted from a coil of wire that carries but 100 amperes? Such a situation is impossible in direct-current practice, but it is perfectly rational in the present instance. As load is thrown across the terminals of section *B*, an equal load arises in section *A*, being in series with *B*, but the energy thus formed in *A* must be expended, so it is converted into magnetic lines of force that appear in the iron bar, which, in turn, must shift the energy so derived into whatever receptive device may be present. Thus it is that the magnetism of the bar is transformed into electric current in the wire of section *B*, which, assuming that there are no losses in conversion, will deliver 100 amperes at 250 volts to the load *L L*. One-half of the load, or 25 kilowatts, thus represents the energy absorbed in section *A* and reappearing in section *B*; the remaining half of the load is taken direct from the main circuit because of the counter electromotive force of the windings of section *B*. Sections *A* and *B* are, therefore, linked together magnetically so that they work as if coupled in parallel for the operation of the load *L L*. In this diagram is found the principle of the autoconverter. Advancing now to the combination in which two rotaries are operated in series from the railway plant, it will be seen that the combination is an exact counterpart of that just given. In Figure 4, the 500-volt generator is delivering 100 amperes to two 250-volt rotaries in series, one of which is connected on its direct-current side to the lighting load of 200 amperes at 250 volts. The alternating-current sides of these rotaries are linked together through raising transformers in which the secondaries are in parallel at 15,000 volts. The path taken by the current as it leaves the generator is indicated by arrows, 100 amperes going first through the direct-current side of the rotary *A* whence it continues, shunting rotary *B*, to the lighting load *L L*, through which it passes, and returning thence to the generator. A current of 100 amperes at 250 volts, or 25 kilowatts, is thus taken from the main circuit and applied to the load direct; but the remaining 25 kilowatts centers in rotary *A*, which, being unable to absorb it as might be done with a rheostat, for instance, delivers it to the two-phase side, whence it continues on through the raising and lowering transformers to the alternating-current side of rotary *B*. This rotary takes the alternating-current and delivers a direct-current of 100 amperes at 250 volts to the load, less losses. Rotary *B* is thus driven electrically from rotary *A* as effectually as though they were mounted on a common shaft. In fact the combination which exists is the same as though it be assumed that *A* is a 25-kilowatt motor in series with one-half of the load *L*, and that the motor

A operates the generator *B*, which delivers 25 kilowatts for operating the other half of the load *L*. In actual practice the rotary *A* is operated at 280 volts, while the rotary *B* is operated at 220 volts, and the higher electromotive force of rotary *A* enables it to drive rotary *B*—the proper variations in the electromotive force being obtained by the manipulation of the regulator dials. The rotaries are coupled in series by means of the "red handle" switches appearing in Drawings Five and Six.

It is evident that the plant is so arranged that it can be operated under several advantageous conditions; for instance, the first advantage was gained from the 500-volt rotary. The electrical end of the transmission plant was ready for operation before the water could be turned in and each day that could be saved on the installation was considered a great advantage. The railroad current at 500 volts was, therefore, run into the sub-station and the 500-volt rotary was used as a direct-current-alternating-current rotary, giving alternating-current which was used for getting the whole plant in operation. The other rotaries were started with this current; all the transformers were dried out and properly filled, etc.; all of the bearings were tested and put in proper condition for operation; all electrical connections completed, synchronizers adjusted and instruments tested, and everything was ready for operation, both at the sub-station and at the generating station, before the water was turned on. This saved about one week's time in starting the plant.

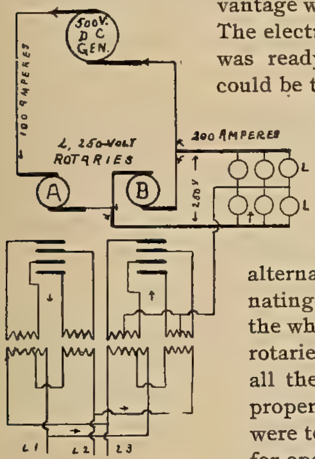


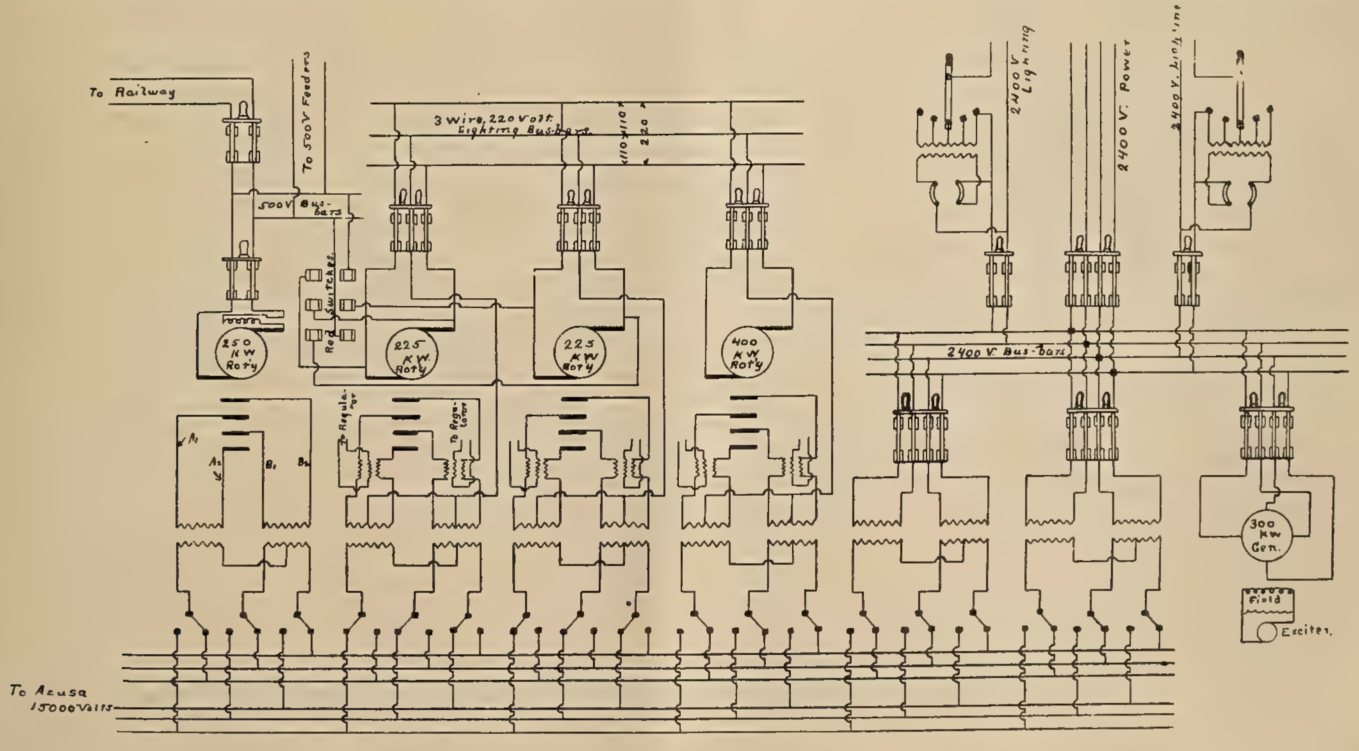
FIGURE 4.

The conditions under which the plant is now operating are equally interesting. The entire day load is carried by the Azusa and auxiliary plants working in parallel; the San Gabriel company has taken over the 500-volt power or commercial motor load of the Los Angeles Railway Company, on which is a direct-current motor driving two Edison generators feeding into the underground mains of the Los Angeles Edison company, which is part of the system of the Southern California Power Company, a competitor of the San Gabriel company; during the peak of the load the 500-volt rotary takes current from the railway plant, stepping it up to 15,000 volts, at which electromotive force it is thrown in parallel with the Azusa and auxiliary plants, and, finally, the main generators of the Los Angeles Edison system are driven by steam and work in parallel with the motor-driven generators just referred to. During the peak of the load, therefore, five different stations are electrically tied together for the delivery of incandescent service, viz: The Azusa water-power plant, the auxiliary steam plant, the San Gabriel sub-station, the Los Angeles railway plant, and the Los Angeles Edison station. In other words, four stations, which are entirely dissimilar in that they deliver 15,000-volt three-phase current, 2400-volt two-phase current, 500-volt direct-durrent, and 220-volt direct-current respectively, are all coupled together in parallel for the operation of two entirely different and independent systems of three-wire direct-current distribution.

The many combinations and varieties of service rendered have necessitated the installation of switchboards of more than ordinary interest. They are divided into five different classes, to-wit: the high tension boards and switches previously described, the alternating-current distributing panels for 2400-volt power and lighting, the rotary converter panels, the 500-volt distributing panels, the three-wire distributing panels, and the panels for the control of the auxiliary steam plant.

SUB-STATION SWITCHBOARDS.

The 2400-volt systems, including the auxiliary plant, are handled from the same switchboard (that at the left in the rear of the sub-station in view on page 96) although independently controlled from separate panels. Beginning from the left, Panel 1 is the exciter and transformer panel, and carries one 100-ampere ammeter; one 150-volt voltmeter; two synchronizing lamps and plugs; one double rheostat for controlling the exciter and generator fields respectively; one voltmeter plug switch; two vacuum break generator field plug switches; two double-pole double-throw switches—one for exciting the auxiliary generator field from the rotary and the other for exciting it from its own exciter; and ten single pole fuse blocks. The latter are the equivalent of dynamo changing switches on the dynamo, transformers and line. They



ROTARIES, GENERATOR, SERVICES
AND TRANSMISSION CIRCUITS

DRAWING SIX.

are arranged with a double set of four 'bus bars each and are never handled when alive. The two sets of 'bus bars are for light and power respectively, and the idea of arrangement is to economize space by avoiding the use of a separate panel for each of the sixteen circuits.

Panel 2, which is the 2400-volt power panel, carries two 100-ampere ammeters; one four-pole double break plunger type high tension vacuum switch for the main line; and eight single-pole fuses as above. The auxiliary generator panel (No. 3) is a duplicate of Panel 2. Panel 4, the 2400-volt lighting panel, carries two 100-ampere ammeters, two double-pole single-throw plunger type switches and eight fuse plugs. From this panel two circuits run out as single-phase mains through Stilwell regulators, as shown in Drawing Six. This panel also supports a swinging arm carrying two voltmeters. Panel 5 is for the 500-volt rotary. It carries one 11-ampere ammeter in the rotary's field, one 600-ampere ammeter in one phase of the alternating-current side, two synchronizing lamps, one field rheostat in the shunt field, one four-pole switch for the induction motor used in starting, and one four-pole two-phase main switch. The 250-volt rotaries are on Panels 6, 7 and 8, the equipment of which are identical with that of Panel 5, except in that the ammeters have ranges of 25- and 1200-amperes respectively. Panel 6 is mainly for the 400-kilowatt rotary, and Panels 7 and 8 are for the two 225-kilowatt rotaries respectively, and they differ only in the range of the instruments.

The 500-volt service is handled by the switchboard facing the 500-volt rotary, or to the left of the direct-current end of the third rotary shown on page 96. Panel 1 is the main panel, and carries an ammeter, voltmeter, circuit breaker and double-pole double-throw switch. Panel 2 is the railway feeder panel, carrying two ammeters, one for the power and one for the railway circuit; one wattmeter on the railway circuit and one double-pole double-throw switch for throwing the two sets of 'bus bars in multiple. Panel 3 carries the red-handled switches for throwing the two 250-volt rotaries in series, as well as being the railway distributing panel. Its appliances are: One ammeter; two double-pole double-throw distributing switches for the railway feeder; two wattmeters, and three single-pole single-throw red-handled switches. Panel 4, called the San Gabriel feeder panel, carries two 500-ampere ammeters and two double-pole double-throw switches for the two sets of 'bus bars on the back of the board. In addition, each of the above four panels has a voltmeter plug switch.

The low tension or three-wire distributing switchboard appears at the left of the interior view referred to, and the first seven panels from the front control seven separate feeders. The appliances on each panel are a pilot lamp, a direct-current ammeter in each three-wire outside lead, a circuit breaker in each outside lead, a voltmeter plug switch, a three-pole single-throw switch controlling the three wires — positive, negative and neutral. This last switch appears only on Panels 1, 2, 5 and 6, while Panels 3, 4 and 7 have only double-pole single-throw switches, the neutral point being omitted. The voltage of these panels is read from swinging Weston voltmeters at the end of the board.

Panels 8, 9, 10 and 11 are for the 250-volt rotaries; the first two being for rotary No. 1, and the last two being for rotary No. 2. Two other panels are to be added for the 400-kilowatt rotary. These panels carry a pilot lamp, a 1500-ampere Weston ammeter, and a main circuit breaker, thus having an ammeter and circuit breaker in each lead of the direct-current side of the rotary. Voltmeter plug switches are in panels 8 and 10, which also carry at the bottom left hand side a locking field switch by means of which the rotary may be either separately excited from the 'bus bar or self-excited. In the center is the main switch in the positive leads. Panels 9 and 11 carry at the left the main neutral switches, and at the right the main switches in the negative leads. In the rear of these panels is the water rheostat used in starting the rotaries from the direct-current side.

The local distribution follows the standard Edison practice closely, differing therefrom only in the use of creosoted wooden ducts instead of Edison tubes. There are sixteen different centers of distribution in the underground conduit area, all of which are reached by 500,000 circular mil cables or 200,000 circular mil mains. Rubber covered wire is used exclusively, and both the 500-volt and 220-volt direct-current services are underground. The neutrals are all connected solid, but the outside wires are fused through a reliable street fuse box designed and built by the San Gabriel company. Manholes are made in the streets as required, and service boxes are placed in front of each separate property. No boosters are used at present, but when it becomes necessary to do so, one of the smaller rotaries will be used as a booster.

At various portions throughout this article are presented characteristic curves concerning generators, transformers or rotaries. These are self-explanatory, but it should be stated regarding them that they were taken by Mr. H. P. Reed, acting as consulting electrical engineer for the San Gabriel company, in order to determine if the apparatus furnished conformed to the specifications under which it was bought. For several years Mr. Reed was employed in the testing department of the General Electric Company at Schenectady, which position he left to enter the employ of the San Gabriel company, but before coming to California he went to Pittsburg where he submitted the apparatus to an elaborate series of tests, a brief portion of which is here incorporated. Mr. Reed's long experience in this line of work leaves no room for doubt as to his competency in testing the forms of equipment submitted to him as well as bespeaking the accuracy of the results.

There is little to be said of the principals of the San Gabriel Electric Company beyond reference to Mr. W. G. Kerckhoff, its president, and Mr. A. C. Balch, its vice-president and general manager, upon whom have fallen the financial and commercial responsibilities of the enterprise. However, particular reference should be made of the fact that the equipment of the sub-station was erected under the direction of Mr. E. W. Crane, while that of the power house was erected in charge of Mr. Phil. S. Taylor, both acting in the employ of the Westinghouse company. When operations began, Mr. Taylor took charge of the sub-station, relinquishing the power house to Mr. Crane, each of whom will probably remain with the plant until winter is over.

PERSONAL.

Of those who have been identified with the engineering features of the work, especial credit should be given to the engineering services rendered by Mr. A. C. Balch, general manager and chief engineer of the San Gabriel Electric Company, Mr. R. S. Masson, electrical engineer of the Pacific Coast office of the Westinghouse Electric and Manufacturing Company, and to Mr. G. O. Newman, engineer-in-charge of the hydraulic development and installation. Mr. Masson requires no introduction to the readers of these columns and an instance of his high attainment as an electrical engineer is found in the statement that to him is due the working out of the ingenious combination above described by which the two 225-kilowatt rotaries are run in series. Mr. Newman has been chief engineer of the Riverside, Cal. Water Company for twelve years and he is recognized as being one of the most proficient engineers in the development and measurement of water to be found in the west.

Mr. Balch first came prominently before the electrical world through his association with the Union Power Company, of Portland, Or., in which, as installing engineer for the Portland office of the Edison General Electric Company, he erected the first electric railway system operating under the Edison three-wire system. In this case, the power plant was located some three miles from the distributing point for the two railways to be operated and distribution at 500 volts, in accordance with the then existing practices, would make the investment in line almost prohibitive. Accordingly it was determined to use the Edison three-wire system, feeding one railway from its positive side, the other railway from the negative side and grounding the neutral. The undertaking proved eminently successful and saved tens of thousands of dollars in copper alone.

To be more explicit as to Mr. Balch's engineering record: He was born on the 13th of March, 1864, near Troy, N. Y., and, in the fall of 1885, entered Cornell University, at Ithaca, N. Y., whence he graduated in 1889 upon completing the course in electrical engineering. During the summer of 1888 he was with the Mather Electric Company at Manchester, Conn., and also was engaged in installing the Mather electric lighting plant in the factory of the American Watch Company at Waltham, Conn. After graduation, Mr. Balch came west to Seattle, Wash., where he engaged in partnership with Mr. Charles H. Baker, (now president of the Snoqualmie Falls Power Company) doing a general engineering business under the firm name of Baker, Balch & Co. About this time Mr. Balch installed the central station plant of the Pacific Electric Company, afterwards consolidated with the Commercial Electric Company and known thenceforth as the Home Electric Company. This was later consolidated with the Seattle Gas and Electric Company, the new plant being called the Union Electric Company. Mr. Balch was engineer in entire charge of these plants until just previous to the formation of the Union Electric Company, and shortly thereafter he went to Portland and entered the service of the Edison General Electric Company as stated. His installation of the three-wire system in the Union Power Company's plant for the operation of railroads and electric power, was an achievement that had been up to that time unequaled in railway work, and, in fact, a marked characteristic of Mr. Balch's engineering career has been a boldness that, when tempered with the sound business judgment and his thorough proficiency as an engineer, has made his every undertaking successful. In October, 1891, Mr. Balch became the electrical engineer of the Union Power Company, and in September of the year following he took a lease of the entire plant, operating it until 1896, when he sold it to the Portland General Electric Company. While in Seattle he secured the franchise in Tacoma afterward utilized by the Commercial Electric Light Company, which purchased the franchise and the partly constructed plant from Mr. Balch. He also installed the central station plant at Blaine, Wash., for Mr. L. H. Griffith. After selling out the plant of the Union Power Company at Portland, Mr. Balch moved to Los Angeles, Cal., where, within a comparatively short time after his advent in that city, he organized the San Gabriel Electric Company, the completion of which attests his engineering and business ability.

All of the electrical equipment of the entire plant from the power house to the lighting and power services, was built and installed by the Westinghouse Electric and Manufacturing Company, with one or two minor exceptions, notably in the use of a few Weston instruments and in the fact that the bulk of the arc lighting is done by enclosed lamps of the "Jandus" and "Pacific" types. The copper for the transmission lines was furnished by the Washburn & Moen Manufacturing Company, that for the underground distribution by the John A. Roebling's Sons Company. Locke triple petticoat glass insulators are used throughout. The Paraffine Paint Company supplied the P. & B. paint used on the cross arms and in the underground work, while the redwood stave pipe along the waterway was built and installed by the Excelsior Wooden Pipe Company, 204 Front street, San Francisco. As previously stated, the water wheels, governors and hydraulic equipments were built and installed by the Oakland Iron Works, of Oakland, Cal. All the tunnel and rock work along the waterway was done by Messrs. Keating Bros., well known contractors of Los Angeles.

DATA OF THE HYDRAULIC AND ELECTRICAL EQUIPMENTS OF THE SAN GABRIEL ELECTRIC COMPANY.

WATER SYSTEM.

Catchment Area: 23 square miles.
Maximum Flow: Flood flow, 30 feet deep where gorge width is 400 feet.
Normal Minimum: 1700 miners inches in surface flow and estimated underflow.
Capacity of Ditch: 4600 miners inches.
Characteristics of Construction: Solid concrete or pipe line throughout.
Length of Ditch: 31,400 feet.
" Tunnels: 20,697 feet.
" Wood Pipe: 8872 feet.
" Steel Pipe in Ditch: 300 feet.
" Concrete Culvert: 1551 feet.
Average Gradient: 5 feet per mile.
Average Speed of Flow: 4½ feet per second.
Gradient of Tunnels: 5.28 feet per mile.
Gradient of Wood Pipe: 10.92 feet per mile.
Width of Tunnels: 4 feet, 9 inches in the clear.
Height of Tunnels: 6 feet to crown of arch.
Depth of Water in Tunnels: 4 feet.
Wood Pipe Material: Selected redwood.
Staves: 6 in. wide; 2 in. thick before rounding; after rounding, 1¾ in. +.
Bands: ½ inch round, wrought iron.
Diameter of Wood Pipe: 48 inches.
Bends in Pipe: No. 8 riveted steel pipe, 50 inches in diameter.
Lumber in Pipe: 221,800 board feet.

PRESSURE PIPE LINE.

Length: 827 feet.
Average Gradient: 45 degrees.
Diameter: 36 inches, except in upper course of 6 feet, which tapers from 36 to 48 inches on entering penstock.
Material: Riveted steel.
Lengths by Gauges: 197 feet No. 11; 164 feet No. 5; 164 feet No. 0; 302 feet No. 0000, enumerating from upper course.
Anchors: 7 in number, placed equidistant along pipe line, and each consisting of 15 feet of concrete work on bedrock.
Safety Devices: Two 6-inch air valves in pipe line; two 3-inch "spring loaded" relief valves on receiver, which also has one 4-inch blow-off at lower end.
Receiver: Length, 40 feet; diameter, 48 inches; of ½-inch riveted steel.

WATER WHEELS.

Type: Tutthill, impulse.
Number of Wheels per Set: 2.
Number of Sets: 4.
Capacity per Set: 550 porse power.
Number of Nozzles per Wheel: 1.
Weight of Flywheel: 6000 pounds.
Speed: 430 revolutions per minute.
Coupling: Flexible leather link.
Buckets: Cast-iron, on alternating sides.
Efficiency: Above 82 per cent.
Governors: 2, Tutthill type.
Manufacturers: Oakland Iron Works, Oakland, Cal.

ELECTRICAL EQUIPMENT.

Azusa Power House. Generators: Four 300-kilowatt, 2-phase, 400- to 500-volt Westinghouse machines, running at 430 revolutions per minute.
Exciters: Three 7½-kilowatt, 110-volt 4-pole machines, running at 1300 revolutions per minute, and belt-driven from generator shaft.
Frequency: 50 cycles.
Transformers: Four 250-kilowatt, oil-insulated, air-cooled Westinghouse, stepping-up from 400 to 500 volts primary 2-phase, to 15,000 to 17,000 volts secondary, 3-phase, by the Scott system.

POLE LINE.

Length: 23 miles.
Line: Two 3-phase, 3-wire circuits, of No. 5 hard drawn copper.
Insulators: Locke, 5½-inch glass.
Separation Between Wires: 24 inches on the sides of the equilaterals.
Cross Arms: Wood, painted with P. & B.; length of upper arms, 6 feet; length of lower arms, 8 feet.
Pole Lengths: Within city limits of Los Angeles, 50 feet; outside city limits, 40 feet. Poles are of Oregon pine, with butts asphalted. At crossings, 50-foot poles with double arms framed.
Pins: Locust, boiled in paraffine and painted with P. & B.
Transposition: Each 3-phase circuit is spiralled one complete turn, the two circuits being spiralled in opposite directions. Each line is ⅓ spiralled 7¾ miles from Los Angeles and 7¾ miles from Azusa.
Telephone Circuit: Iron; transposed every 5 poles; on brackets on same side of poles, from 3 feet to 10 feet below power lines; induction inappreciable.

ELECTRICAL EQUIPMENT.—LOS ANGELES SUB-STATION AND PLANT.

Transformers, by Capacities: Two 125-kilowatt, reducing from 15,000 to 2400 volts; two 150-kilowatt, reducing from 15,000 to 360, 375, 425, or 460 volts; and four 125-kilowatt, reducing from 15,000 to 218 volts; two 150-kilowatt, reducing from 15,000 to 2400 volts, together with four series transformers used for regulating purposes. Total capacity, ten transformers, 1750 kilowatts.
Type of Transformers: Westinghouse, oil-insulated, air-cooled.
Generator: One 300-kilowatt, 2400-volt, 2-phase, 50-cycle, rope-driven, Westinghouse, at 430 revolutions per minute.
Exciter: One 7½-kilowatt, 110-volt, 4-pole Westinghouse, at 1300 revolutions per minute.
Rotaries: One 250-kilowatt, 500 to 550-volt D. C., transforming from 360, 375, 425, or 460-volt A. C., or vica versa, at 500 revolutions per minute; two 225-kilowatt, 220-320-volt D. C., transforming from 218-volt A. C., or vica versa, at 500 revolutions per minute; one 400-kilowatt, 220-320-volt D. C., transforming from 218 volts A. C.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of
Electricity and Transmission of Power.

Official Organ of the Pacific Coast Electric Transmission Association.

Subscription invariably payable in advance. Terms—Domestic, One Dollar per Year; Foreign, Two Dollars per Year. The trade supplied by the San Francisco News Company. Advertising rates furnished on application.

GEO. P. LOW, : : : Editor and Proprietor

PUBLICATION OFFICE:
320 CALIFORNIA STREET,
ROOM 14.

Address all communications to
Editorial rooms, 427 TENTH AVE.
Telephone, "Steiner 623."

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME VI NOVEMBER, 1898 NUMBER 5

EDITORIAL.

POLYPHASE CURRENT DISTRIBUTIONS.

The relative merits of two and three phase current distributions are discussed by Mr. Andrew Stewart in a recent issue of *Electricity*, London, who in answer to a question as to the conditions under which it is desirable to choose a two or three phase system, points out that the fact that both are successfully supplying light and power from the same circuits does not mean that they are equally suited for the purpose. The author does not agree with the statements made by the advocates of three-phase currents that three-phase motors give a more uniform torque and a higher power factor than two-phase motors, and after discussing the liability of the three-phase system to become unbalanced, reaches the conclusion that the necessity for maintaining a well-balanced line renders it unsuitable for the general distribution of light and power when both characters of service are delivered from the same circuits. It is impossible to control any one phase of a three-phase circuit independent of the other two phases, because the three circuits are electrically interlinked, hence the application of the three-phase system seems to be confined to simple power distribution in large units, or to any purpose where the current may be kept approximately the same in all three lines.

Two-phase presents many advantages, especially where single-phase is already installed, as it is easy to feed a single-phase network, as such, from a two-phase generator; there is also an entire absence of balancing troubles, as a two-phase generator may be run with one phase fully loaded and the other half loaded, with scarcely any variation of the pressure, while even this may be eliminated by regulation. The ease with which one phase may be controlled independent of the other renders it extremely useful in supplying a mixed system of light and power, as in such cases it would be practically impossible to get the load equal on both phases. Nearly all the regulating devices used on single-phase may be used on two-phase, thus rendering easy its introduction into places where single-phase is already installed. Indeed, two-phase seems to give all the advantages of multiphase distribution, with the flexibility and ease of control so characteristic of two-phase.

In factories where the distribution of light and power by polyphase currents has been coming to the front of late, there seems in many cases little to choose between two and three phase currents. In most cases a large motor load has to be supplied, and as the lighting load goes on and off with fair regularity, and is generally under the control of the engineer in charge, unbalancing troubles are not so much to be feared. Thus three-phase meets all requirements. However, electric welding has to be considered, and as it is desirable, wherever possible, to use only one type of plant inside a works, the suitability of the generator to supply current for welding transformers is important. Here two phases scores decisively. It is a matter of no difficulty to supply a welding transformer from one phase of a two-phase generator, while to do the same from a three-phase generator would be to upset the balance of the entire system, causing lamps on one side of the network to burn dim, arc lamps to flicker, and a general derangement of the entire system.

One important point should not be overlooked, that is, cost of copper. This is greatly in favor of three-phase, while on the basis of maximum stress on insulation, the direct current, three-wire system is most advantageous. Although three-phase has such a large advantage over its rivals in the matter of cost of copper, this does not have much influence in the cost of power transmission in factories, where the cost of copper seldom exceeds 30 per cent. of the total cost, and when compared with flexibility and ease of control of two-phase, it will be no great advantage to give three-phase the preference, except where very large amounts of power must be transmitted.

It will be seen from the foregoing that both systems have distinct merits of their own, and in course of time each will have its own position in the engineering world.

THE SNOQUALMIE PLANT.

The opening month of the new year will witness the inauguration of two noteworthy transmissions, the first of which will probably be that of the Southern California Power Company, with its eighty-mile, 33,000-volt line into Los Angeles, and closely following which will be the starting of the transmission of the Snoqualmie Falls Power Company into Seattle and Tacoma. This plant is of especial interest because of its high voltage, its capacity, and its use of aluminum wire — the Snoqualmie company being the first to use aluminum on a long distance power transmission line. A statement of the present condition of the work is therefore of timely interest.

The pole line will be completed from Snoqualmie Falls to Seattle, a distance of thirty-one miles, about December 15th. The poles will carry six wires, each 263 mils in diameter, arranged in two three-phase circuits, one on each side of the pole, and each circuit being in the form of a triangle having thirty-six-inch sides. One of the circuits will be spiralled at six points between the Falls and Seattle, the object being to obtain two changes in the arrangement of the wires between the Falls and the three points at which the circuits will be tapped. Aluminum wire is shipped in lengths of approximately 1500 feet and joints in it are made with a tubular sleeve slipped over the two ends and firmly twisted. The elastic limit of the size of wire used, which is equal in conductivity to No. 4 B. &. S. copper wire, is 800 pounds, and all tests have shown the sleeve joint to be stronger than the wire proper. This wire has a conductivity of sixty per cent. of that of copper of equal cross section, and its weight is about one-half of that of No. 4 copper wire. The Snoqualmie company is using No. 8 B. & S. aluminum for tie wires, and No. 10 aluminum for the telephone circuits. The Redlands type of porcelain insulator is used; the locust pins have five inches of pin between the base of the insulator and the top of the arm, and all pins were boiled in oil. The step-up transformers are adapted to deliver current at an electromotive force of 14,500 or 15,000 volts, and 29,000 and 30,000 volts. The two circuits to Seattle are planned to deliver 4000 kilowatts at 25,000 volts with a loss of fifteen per cent. of the energy delivered.

The transmission line to Tacoma, on which work has not yet been commenced, will parallel the Seattle line, at a distance of forty feet therefrom, for nineteen miles from the Falls, at which point all the circuits will be taken to a plug switchboard to give all possible interchangeability in case of trouble on one of the circuits. From this common point the line will be constructed to Tacoma, a further distance of twenty-six miles. Drawn on paper, the two lines form a Y with the left hand upper portion some fourteen miles longer than the upper side. The common point is Renton, a small town at the south end of Lake Washington, and where it is proposed to install a substation for a local distribution. The Tacoma line will also carry two circuits that will be similar in all respects to the Seattle lines except that the aluminum wire will have a diameter of 233 mils. This line will probably not be erected until the severity of winter has passed.

It has already been stated in these columns that the generating equipment will consist of four 1500-kilowatt, 1000-volt, revolving armature, three-phasers. There will also be twelve 500-kilowatt raising transformers and a practically equal capacity in lowering transformers of 300 kilowatts and 500 kilowatts each, to suit the local requirements. The comparatively high transmission frequency of 7200 alternations has been selected with reference to furnishing alternating current arc lighting. The first generator was shipped on November 15th and it is expected that the Seattle line will be put in service on January 15th, which is the date fixed for the operation of the Centennial Flouring Mills from two 200 horse-power induction motors.

The Snoqualmie plant will be the second great transmission in the Pacific Northwest—that of the Portland General Electric Company being the other—but the fewness of noteworthy transmissions within its borders must be attributed to cheap fuel and not to lack of enterprise on the part of the local engineers, nor to any inappreciation of the value of the numerous water powers there to be found. High voltages for transmission purposes and the ability to apply electrically transmitted energy to almost every conceivable purpose with equal if not greater satisfaction and reliability than is possible from any other source, have together combined to make such transmissions possible in a country where coal and wood fuel abound.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

NOTEWORTHY CURRENT TRANSFORMATIONS.

The remarkable combinations that have been used by the San Gabriel Electric Company, as described in the leading article of this issue, makes especially interesting the contribution of Mr. Charles F. Scott on "The Evolution in Central Station Practice" appearing in *The Engineering Magazine* for November, in which is described as typical instances of the flexibility of polyphase currents, the transformation of current as practiced at Niagara Falls and at Hartford. Without doubt, the San Gabriel transmission must now be enumerated in the list of the world's most noteworthy current-transformation installations, for while its electrical combinations are not as numerous as are those of Niagara, they are more so than at Hartford, and they are equally if not more heroic than the combinations of either plant separately.

Mr. Scott's article produces an interesting diagram showing the transformation of current from the two-phase generators at Niagara Falls. All the power from the 5000 horse-power generators is delivered as two-phase alternating current, at 2000 volts and a frequency of 25 periods per second. Four wires are carried directly from the generators to the surrounding establishments. Current is transformed to low voltage and then converted into direct current at 550 volts for railway service. It is also converted into direct current at 160 volts for use in the production of aluminum. Elsewhere it gives direct current at variable voltage, adjustable at will from 125 to 165 volts in one case, and from 170 to 230 volts in another, to meet the varying requirements of electrochemical processes. It is used as alternating current at low voltage for producing intense heat in chemical manufacture, in some places at a constant voltage, and in another at variable voltage. Regulators are provided by which 1000 horse-power can be delivered in the form of 3750 amperes at 80 volts or any intermediate current and corresponding voltage. The current supplies induction motors of 400 horse-power and smaller sizes, some for replacing engines in lighting stations, others for doing various work in factories, sometimes directly at 4000 volts, sometimes at low voltage.

The current is transformed into three-phase current at

11,000 volts for transmissions to greater distances. At Tonawanda there are rotaries for delivering direct current to the Niagara and Buffalo railway, and there are distributing circuits for supplying electric current for power and light. At Buffalo current is reduced in pressure and converted into direct current at 550 volts for street railways and for stationary motors. It is converted into direct current for 220-volt three-wire distribution; it runs motors which replace engines in lighting stations for driving dynamos for arc lighting and for high frequency incandescent lighting; it runs motors in grain elevators and various industries and supplies incandescent lighting.

At Hartford, Conn., are two sources of power—a water-power, ten miles from the city, which drives alternating current generators delivering current through raising transformers to a three-phase 10,000-volt transmission circuit and to a steam engine located in the city. This engine drives a countershaft from which are belted a number of arc machines, the countershaft is connected to an alternating current machine which may be driven by the engine for supplying power to the alternating circuits, or this machine may receive current from the transmission line and run a synchronous motor, driving the countershaft and arc machines. There are rotary transformers in the city which receive alternating current either from the water-power station or from the steam station, and deliver this power in the form of direct current which is supplied either to the 220-volt three-wire distributing system or to a large storage battery. The storage battery may, in turn, serve as a source of power, from which current may feed into the direct current distributing system; or, passing through the rotary, it may appear in the form of alternating current which may either supply the alternating current distributing circuits, or pass to the sychronous motor and be used for arc lighting.

Either the water power or the steam engine of the Hartford plant may, therefore, supply either the arc circuits, the alternating circuits, the direct current circuits or the storage battery. The latter may in turn supply power to any of the three classes of distributing circuits. The storage battery is charged when the load upon the distributing circuit is small and it discharges when the demand is greater than the capacity of the water-power station, thus enabling the turbines to carry a load of some 50 per cent. above their maximum output. The battery is also a useful regulator for both direct and alternating circuits, to prevent variations of voltage with varying load. The steam plant is a reserve.

◆ ◆

"SYNCHRONOUS VS. INDUCTION MOTORS."

On page 76 of the present volume was reprinted an article under the above caption containing the following statement, which is somewhat misleading: "The ordinary method of expressing the magnitude of wattless and energy currents—namely, by the power factor percentage—is, by the way, a snare and a delusion. A power factor of 99 or 94 per cent., values often obtained with large induction motors at full load, gives the impression that the wattless currents are only from six to ten per cent. of the total, whereas, on account of the vectorial relation, the wattless currents are in the one case one-third and in the other case one-half as great as the energy currents, giving in combination with the self-induction of generators, lines and transformers, corresponding reactive voltage drops."

It is true that the components representing the wattless currents in the cases mentioned are one-half and one-third as great as the energy currents when laid off in vectorial diagrams. The wattless components, however, are at right angles to the energy currents, and therefore the actual current flowing on the line is the resultant or geometrical sum of the two currents. The actual current appearing on the ammeter is, therefore, approximately in the one case 10 per cent., and the other 5 per cent. greater than the energy current. The losses on the line due to inductance and ohmic drops would be in the proportion of 10 and 6 per cent. and not 50 and 33⅓ per cent., as implied by the above-quoted statement.

◆ ◆ ◆

A TELEPHONE MAGAZINE AT LAST.

After weary years of anxious waiting, the tens of thousands of electrical workers that are employed in the telephone industry have a publication devoted exclusively to telephony, and, what is of far greater import, this publication bears every evidence that it is worthy of the support of the great electrical interest it represents. The publication referred to is none other than *Electrical Engineering*, which has been acquired by new owners, principal among whom are John C. McMynn and C. E. Kammeyer, and with the change in ownership has come a radical change in policy, for *Electrical Engineering and Telephone Magazine* now openly advocates the independent telephone movement.

Congratulations are extended to the telephone interests on the appearance of so highly creditable a publication devoted to their interests.

◆ ◆ ◆

RIEHLE'S "DIGEST" SUSPENDS TEMPORARILY.

It is with genuine regret that note is made of the temporary suspension of *Digest of Physical Tests* with the issue for October, and the void that this suspension creates in engineering literature is one that will be hard to fill. As to the cause, the announcement is made that the many demands upon the time of Mr. Joseph W. Bramwell, editor, for new developments in the line of testing machinery, together with the general activity in the business of Riehle Bros.' Testing Machine Company, of which he is superintendent, makes a suspension imperative. The hope that the publication will soon be resumed will find its echo from all.

That THE JOURNAL'S articles on electric transmission are appreciated beyond local spheres, is evidenced by the fact that its foreign subscription list has quadrupled, and its Eastern list has increased ten-fold, in six months.

Personal

Robert Bruce Elder, who has long been recognized as one of the most successful salesmen of electrical apparatus on the Pacific Coast, entered the electrical business immediately upon graduating from the high school of his native city, San Francisco, in 1887, his first association being as draughtsman with the Electric Development Company, which held the original Edison agency for the Pacific Coast. It was through this company that Mr. J. C. Henderson, afterward chief engineer of the Edison General Electric Company, became so well known on the Pacific Coast during the early days of the electrical industry, and associated with him were Messrs. Geo. D. Ladd, Percy T. Morgan, and F. W. Eaton — all names since prominent in electrical enterprises in California. The old "Z" type, long field Edison dynamos represented the highest perfection of the art at that time, and there were installed several plants that are now looked upon with historical interest, the most noteworthy being on the San Francisco-Portland steamship "Columbia," and in the Spreckels sugar refinery at San Francisco. A year or so thereafter the alternating current system came into prominence out west, and Mr. Elder became connected with the San Francisco office of the Westinghouse Electric and Manufacturing Company almost at the very inception of its Pacific Coast agency. About the first work undertaken by it was the installation of the Westinghouse system in the Baldwin Hotel, San Francisco. Mr. W. A. Burkholder was in charge of the erection of the Baldwin plant, and young Elder's first work of a practical nature was as a wireman on the job, and the next work of prominence in which Mr. Elder was employed was the installation of the Westinghouse plant in the Southern Pacific shops at Sacramento. The organization of the Pacific Electrical Storage Company and the interest that had arisen in the storage of electricity, occasioned the next change that was made in Mr. Elder's connections, and he became associated with the new concern in the dual capacity of salesman and superintendent of installation. Mr. Frederick Reckenzaun, brother of M. A. Reckenzaun, whose names are intimately connected with the development of electrical accumulators, was the electrician of the company, but when it was found that the scheme for establishing a factory in San Francisco could not be carried out, Mr. Reckenzaun resigned and returned to the east, and Mr. Elder succeeded to his interest and position in the Pacific Electrical Storage Company. Some very interesting storage battery installations were made under Mr. Elder's direction, among which may be enumerated the Swain, Edenvale, Benicia, Reno, Fair, and Pleasanton plants. Mr. W. S. Heger, now manager of the San Francisco office of the Westinghouse Electric and Manufacturing Company, was then manager of the San Francisco office of the United Edison Manufacturing Company, and a friendship between him and Mr. Elder developed at that time which has since grown into the closest possible relations. In fact, throughout the years that intervened from the first year of 1890 to 1896, when Mr. Heger was appointed to his present position, it was the hope of both parties that they might ultimately be associated together, and this desire was gratified when, in September, 1896, Mr. Elder became identified with the San Francisco office of the Westinghouse Electric and Manufacturing Company. His success as a salesman in this capacity has been remarkable, and one of the many evidences of his ability in this direction rests in the fact that he carried on the negotiations and executed the contract resulting in the sale of Westinghouse apparatus exclusively for the use of the San Gabriel Electric Company's Azusa-Los Angeles transmission, so fully described in this edition. Mr. Elder is of the character best described as bright and clear cut, and these qualifications, coupled with a merry, pleasing personality and a sound judgment of engineering matters, combine to make him what he is: one of the most agreeable and successful salesmen to be found in the electrical business.

ROBERT BRUCE ELDER.

Prof. A. Van der Naillen, president of the Van der Naillen School of Engineering, San Francisco, has returned from a six months' trip through the continent of Europe, whither he went to study the most recent advances that have been made in electrical science since his last visit there, less than two years previous. As a portion of the fruits of the trip, the class in electrical engineering of the Van der Naillen school is to be equipped with considerable new electrical apparatus, not the least interesting among which is the Marconi system of wireless telegraphy.

Mr. I. C. Woodward has resigned the managership of the electrical department of the Dunham, Carrigan, Hayden Company to accept the position of sales agent for the Pacific Arc Lamp Company of San Francisco.

Mr. Robert McF. Doble has been appointed consulting and supervising electrical and mechanical engineer for the Mount Whitney Power Company, with headquarters at the company's offices, 202 Sansome street, San Francisco.

Mr. C. P. Gilbert, the well known organizer and past president of the Pacific Coast Electric Transmission Association, has resigned the general managership of the Sacramento Electric Gas and Railway Company and has accepted a like position with the Standard Electric Company of California, with offices in the Crocker Building, San Francisco.

Mr. A. M. Hunt, who retired from the firm of Hasson & Hunt to accept the engineership for the department of navigation of the Alaska Commercial Company, has returned from Alaska, whither he went in February last. He will not return north until next spring, if then, and will probably spend a portion of the winter in the eastern states.

Mr. C. E. Dutcher, the well known electrical engineer, has been appointed engineer for the Comstock Mining Association, and the duties of the position, which will require all his time, have necessitated his removal to Virginia City, Nevada.

Mr. Albert Gallatin, vice-president of the Sacramento Electric Gas and Railway Company, will hereafter execute the duties of general manager of that corporation, vice Mr. C. P. Gilbert, who, as stated elsewhere, has resigned.

Mr. J. W. Horner, has resigned his former position with the San Francisco office of the General Electric Company to accept that of traveling salesman for the Brooks-Follis Electric Corporation.

Transmission

THE RATIOS OF ROTARY CONVERSIONS.

According to Professor S. P. Thompson in a paper on "Rotary Converters," read before the Institution of Electrical Engineers, London, November 10th, if direct-currents are supplied at a constant pressure of 100-volts at the brushes of the direct-current side of a rotary converter, the voltmeter readings at the alternating-current side will be as follows:

Number of Collector Rings.	Angle of Connection to Rings.	Nature of Service Generated.	Voltage Ratio.	Virtual Volts.
2	180°	Single-phase	$\frac{1}{\sqrt{2}}$	70.71
3	120°	Three-phase	$\frac{1}{2}\frac{\sqrt{3}}{\sqrt{2}}$	61.23
4	90°	Two-phase	$\frac{1}{\sqrt{2}}$	70.71
4	90°	Four-phase	$\frac{1}{2}$	50.00
6	60°	Three-phase	$\frac{1}{2}\frac{\sqrt{3}}{\sqrt{2}}$	61.23
6	60°	Six-phase	$\frac{1}{2\sqrt{2}}$	35.35

A very complete discussion of these voltage relations, with formulæ applicable to the cases of open-coil windings as well as of closed-coil windings, was given by Herr R. M. Friese in the *Elektrotechnische Zeitschrift* of February 15, 1894, throughout which the author assumes the sine values of the distribution of the magnetic flux around the periphery of the armature. More recently Mr. Steinmetz has reconsidered the same problem in the same journal in articles which appeared on March 3d and 10th, 1898. Professor Thompson states that from the theoretical conditions there given, it is easy to compute not only the voltages in the several cases, but also to calculate the corresponding relative values of the working currents in the armature and line wires.

AN EXPONENT OF PROGRESS.

A well known scientist, than whom none on the Pacific Coast is more thorough, whose writings have appeared in the very best magazines the country over, and who, presumably, would prefer that his name be withheld, has written the following very gratifying letter to the editor of this magazine:

> I am leaving the Coast this week, and before going, I had hoped to find time to call on you; but this will not be possible now. Something I must say to you, however, and that is that you should know how a layman regards your work in connection with The Journal of Electricity. The magazine is a credit, not to the Coast alone, but to the whole country, and I trust it may maintain always its present high standing. I have many journals, in fact my desk overflows with them, but few of them have given me the downright information and instruction that the Journal has. Great are the problems in electrical engineering yet to be tackled and mastered on this Coast. May you be, as now, an exponent of progress in this direction.

Literature.

"Electricity in the Diagnosis and Treatment of Diseases of the Nose, Throat and Ear." By W. Scheppegrell, A. M., M. D. With 161 illustrations. Published by G. P. Putnam's Sons, New York, 1898. 8vo. of 371 pages; 13 pages Bibliographical references; 18 pages index.

So many volumes of trash on "Electro-Therapeutics" have passed through our hands that even the publishers' name on the title page of the present volume was not enough to remove the preparatory feeling of repugnance with which this work, one of the most recent in electro-therapy, was taken up for review. But the excellent quality of the contents came as a most refreshing change and pleasant surprise. So great has been this feeling of pleased relief that we are in danger of forgetting to temper the praise which we would bestow with the word or two of unfavorable criticism which is indicated. Let us be done with the adverse criticism first and then resort to the more pleasant task of noting the excellent features of the work. The same old fault of printing cuts taken bodily from manufacturers' catalogues, without even effacing the dealer's name from the cut, is found in this as in all other books on electro-therapeutics which we have ever seen. Why such cuts should be used is a mystery not yet solved; it can not be the question of expense, for the added expense of making new cuts would be but a trifle in comparison with the total cost of the book. These cuts are always poor in quality and ugly in appearance, and so detract much from what would otherwise be a remarkably good specimen of the bookmakers' art. There are some lapses from grammar, and one or two inaccuracies in electro-physics, but aside from these small errors the text is beyond reproach.

The author does not spend too much useless space on the consideration of questions in electro-physics, but goes into them deeply enough for anyone not undertaking the study of electricity as a branch of science. The first ninety-seven pages are devoted to considerations of the various apparatus and the relative value of different forms and makes. It is indeed pleasant to note that he has strongly advocated the use of the direct incandescent lighting circuit, by means of proper apparatus, for all forms of therapeutic work. And his discussion of this question alone is a clear indication that he is fully acquainted with the subject on which he writes. The relative values of the various makes of cells are given, and the results of careful tests of apparatus and measuring instruments are also included in this portion of the work. Forty pages are devoted to the question of "Transillumination" as employed in the diagnosis of disease of the maxillary sinus and to the subject of the electro-cautery. The following pages deal with cataphorisis, interstital electrolysis, electro-magnetic appliances, (including magnetic laryngeal tube extractors, drills, motors, mechanical nasal saws, devices for mechanical massage of the ear and larynx, etc.) tumors of the nose, throat, larynx, and nasopharynx, diseases and deformities of the nose, diseases of the tonsils, neuroses, and application of electricity to the ear. The last twenty-five pages are devoted to an excellent consideration of the X-rays.

One of the most valuable features of the book is the bibliographical index; the author has here enumerated 565 books or articles on the subject of electro-therapeutics, with especial reference to the specialties on which he is writing. The book is written in a clear, exact, methodical style, with copious references to the work and experience of others; it carefully considers and sifts the vast amount of matter that has been printed on the subject, and the conclusions reached are founded on experience and data, rather than upon enthusiasm and ignorance, as is the general rule. The total result of medical research in the lines embraced by the author, is represented in this one volume. It is one of the very few books of the year that are of any value.

Philip Mills Jones, M. D.

Mining

ELECTRICITY IN MINING.—V.*

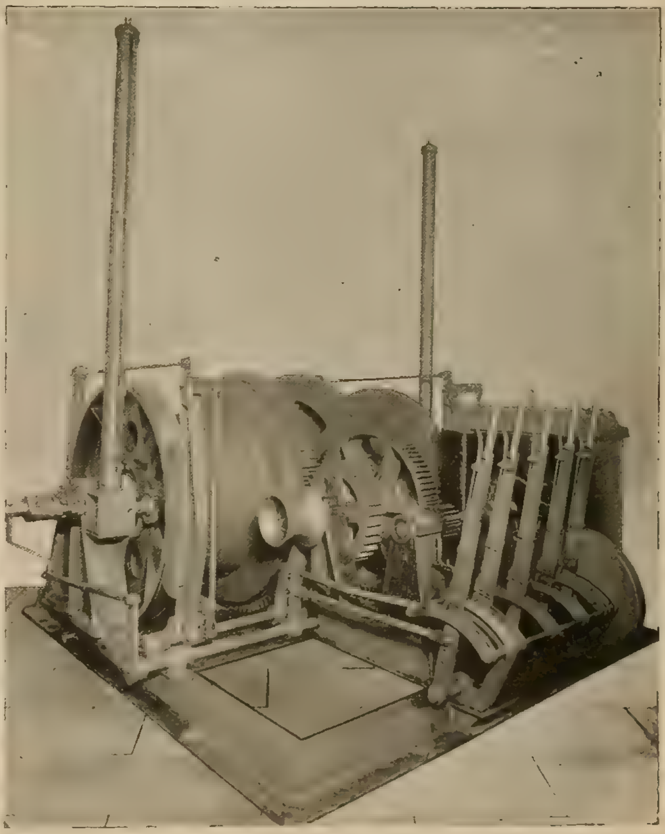
DIRECT current machinery is used more extensively in mining operations at the present time than is the apparatus of the alternating or polyphase types, and this is due to several reasons, principal among which are the facts that direct-current machinery was introduced and practically perfected before the principles underlying the operation of alternating-current machinery were discovered; and that alternating or polyphase motors, though highly efficient and embodying the acme of perfection in many mechanical and electrical standpoints, have not been widely installed for the operation of mining hoists owing to the fact that they are inherently so constituted that they work to a disadvantage under unsteady or intermittent loads. Of late, however, these inherent difficulties are being rapidly overcome as will be shown during the progress of this series of articles, but the purpose of the present contribution is to discuss the uses of direct-current apparatus as applied to a typical California mining installation.

FORMERLY THE ZANTGRAF MINE. THE MONTAUK GOLD MINE, EL DORADO COUNTY, CAL.

A reason for the success which has attended the operation of mining hoists from direct-current motors is found in the properties it possesses of running at practically uniform speed independent of its load, of taking current in almost direct ratio to the load, and of being under perfect control as to speed and direction of rotation. On the other hand, difficulties in commutation prevent the long distance transmission of electric power by direct currents and limits their sphere of usefulness to within a few miles at best from the power plant, for without high potential, transmission over material distances is commercially impracticable owing to the prohibitive cost of copper necessary to carry the low tension current.

Direct current is, therefore, eminently suited for duty within a comparatively short radius from the power plant, and the plant installed by the Electrical Engineering Company, of San Francisco, in the old Zantgraf mine of the Montauk Gold Mining Company, in El Dorado county, Cal., conforms admirably to these conditions, hence a description of its electrical equipment is pertinent at this time. The generators of the Montauk mining plant are in two units, of 125 and 70 horse-power respectively, each being run at 500 volts, and each being separately belt-driven from a 36-inch water wheel. The power house is located on the opposite side of the American river at a distance of 2700 feet from the mine, and water for driving the wheels is taken from an irrigating ditch supplied from a dam across the same river below Auburn. The water is applied to the wheels at an effective head of 120 feet and is paid for at a given rate per miners inch. These generators each supply a separate circuit, one of which is of No. 0, B. & S. gauge and the other of No. 0000. Of these, principally the hoist, is run on the No. 0000 circuit from the larger generator, while the rest of the equipment is run from the smaller generator over the other circuit.

Interest in the equipment naturally centers in the hoist, a view of which is presented on page 110. On this page is a view of a similar hoist having a single motor, which is given in order to show the method of gearing used. That in the Montauk mine is a double reel hoist, the moving parts of which are mounted on a cast iron bed plate and are self-contained. The drums are 40 inches in diameter, with 24-inch face and have deep flanges to contain from 1500 to 2400 feet of three-fourths-inch rope. Each drum is independent of the other and may be thrown in or out while the gears are in motion, and, moreover, each is provided with bronze bushings which may be replaced in case of wear. The hoist is driven by two 30 horse-power motors through double reduction gearing, each armature being geared independently to secondary gear wheels which have a common shaft. As will be seen, the motors are of the bi-polar type and their fields are commutated at the controller so that the energy ordinarily



SHOWING THE GEARING OF THE MONTAUK HOIST.

---

*Continued from Volume VI, page 41.

lost in the rheostat in starting is thrown upon the field windings, producing a highly over saturated field, which in turn, enables the motors to deliver the high starting torque so essential in the operation of mining hoists. The levers shown at the left in the illustration enable proper manipulation of the equipment and the controller gives seven different speeds, varying the travel of the skip from 50 to 500 feet per minute.

The shaft descends at an average angle of 52 degrees and is in double compartment. The skips weigh about 1000 pounds each and have a capacity of forty cubic feet each, or about two tons of ore. Three-quarter-inch steel rope is used and the sump is now below the 800 foot level. The trip is made in less than two minutes when a single skip is being hoisted. The accompanying tables give the observed readings taken for single and double skip loads during actual service. At the start in the former the controller was thrown to the fourth notch when the current jumped momentarily to 110 amperes, quickly falling to 100 amperes and then to 90, which appears as the reading at the 800 foot level.

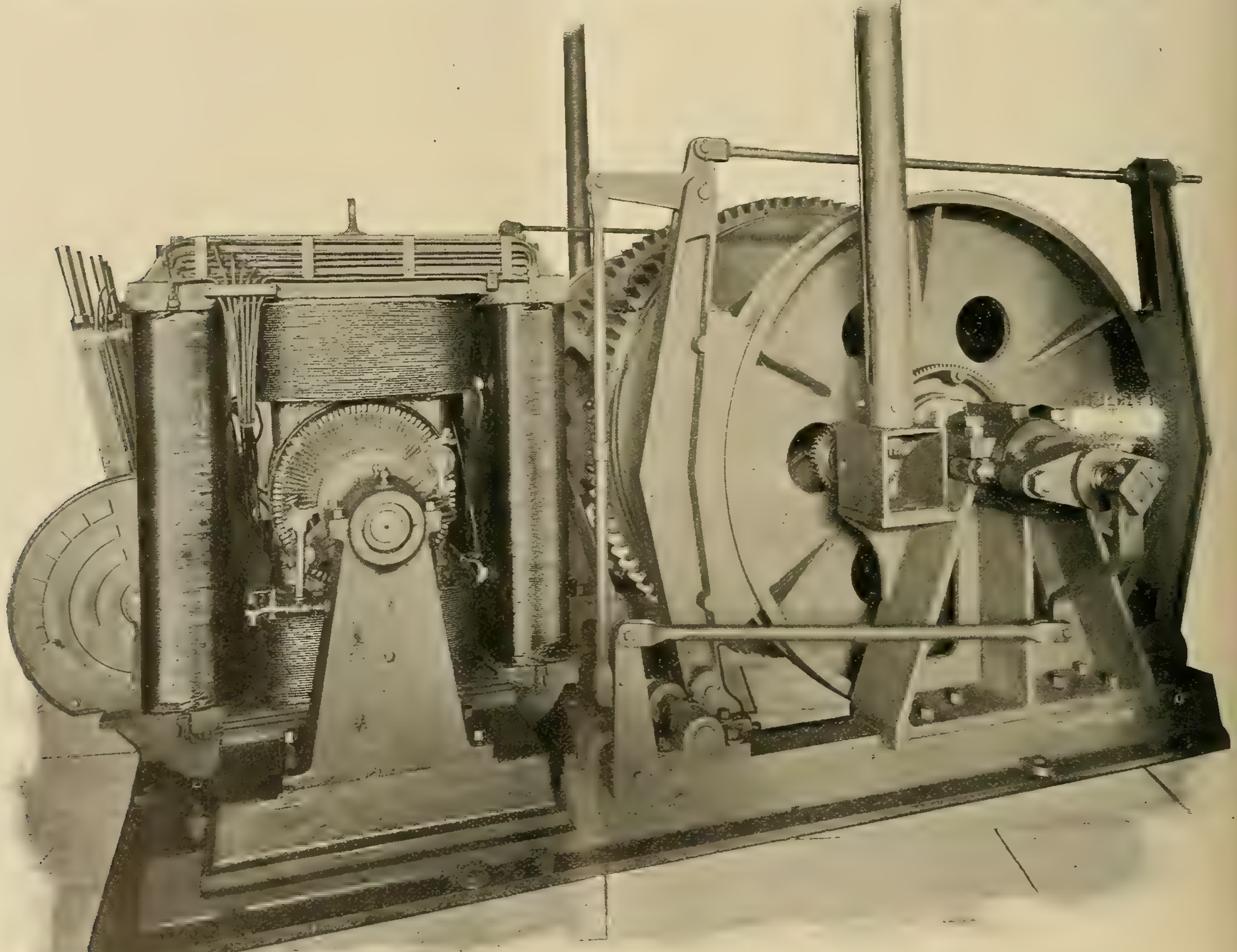
The time consumed in this trip was one minute and fifty seconds, giving an average speed to the skip of 436 feet per minute. In the other test with a double load, the start was made on the fifth point of the controller when the ampere needle jumped to 160 amperes, dropping to 120 amperes in about ten seconds, after which the readings given were taken. The time consumed with the double load was two minutes and fifteen seconds, giving a speed of 356 feet per minute.

The observed readings are as follows, Weston instruments being used:

Level	SINGLE LOAD.			DOUBLE LOAD.		
	Amperes	Volts	Watts	Amperes	Volts	Watts
800	90	450	40,500	120	400	48,000
700	80	450	36,000	120	400	48,000
600	80	450	36,000	110	400	44,000
500	70	475	33,250	110	400	44,000
400	65	475	30,875	105	410	43,050
300	60	500	30,000	100	425	42,500
200	60	500	30,000	100	425	42,500
100	60	500	30,000	90	450	40,500

In addition to operating the hoist, the 125 horse-power generator delivers current for driving a 10 horse-power motor operating a pump at the 600-foot level, and a second 10 horse-power motor which runs a rock breaker in the mill. The pump, which is of the double acting plunger type driven under double reduction, delivers water from the mine through a tunnel at the 200-foot level.

The 70 horse-power generator operates a ten horse-power motor-generator set which delivers current at 110 amperes to the incandescent circuits. A 10 horse-power motor in the pumping station in the ravine below the mill takes water from the irrigating ditch across the river and lifts it against a head of 90 feet to the m



DRIVEN BY TWO 30 HORSE-POWER DIRECT-CURRENT MOTORS. DOUBLE REEL HOIST IN THE MONTAUK MINE.

whence it is used as battery water; and, finally, a 40 horse-power motor is belted direct to the main shaft from which is driven the mill of twenty stamps. The managers of the property expressed the greatest satisfaction when questioned regarding the operation of the plant.

Originally the mine was driven by a 70 horse-power Corliss engine furnished with steam from tubular boilers that burned wood at $5.00 per cord, and, before the generating station had been installed, the mill motor was used as a generator by the Corliss engine, and the hoist was driven at slow speed therefrom during the period when the shaft was being sunk the last 100 feet. At that time over 50,000 gallons of water per day was being lifted from the mine. The attendance for the steam and electric plants is about equal, and while the interest on the latter is higher, the fact that the water costs only one-half as much as wood fuel formerly did, has made the change from steam to electric power a most advantageous one from every financial and operating standpoint.

Hydraulics

A THIRTY-FOOT IMPULSE WATER WHEEL.

THE perfect satisfaction which has attended the operation of the eighteen-foot water wheel installed in the North Star mine, near Grass Valley, Nevada county, Cal., in the fall of 1895, has been so great that when, a few months ago, it became necessary to increase the power plant of the North Star Mining Company, it was promptly decided that the new extension should be strictly along the lines of the old plant, so far as the type of wheel and air compressor is concerned. The entire plant as originally installed was fully illustrated in THE JOURNAL OF ELECTRICITY for November, 1895, and the present wheel, which is over half as large again in diameter as the old one, affords a striking instance of the marked advance that has been made in mechanical engineering in three years.

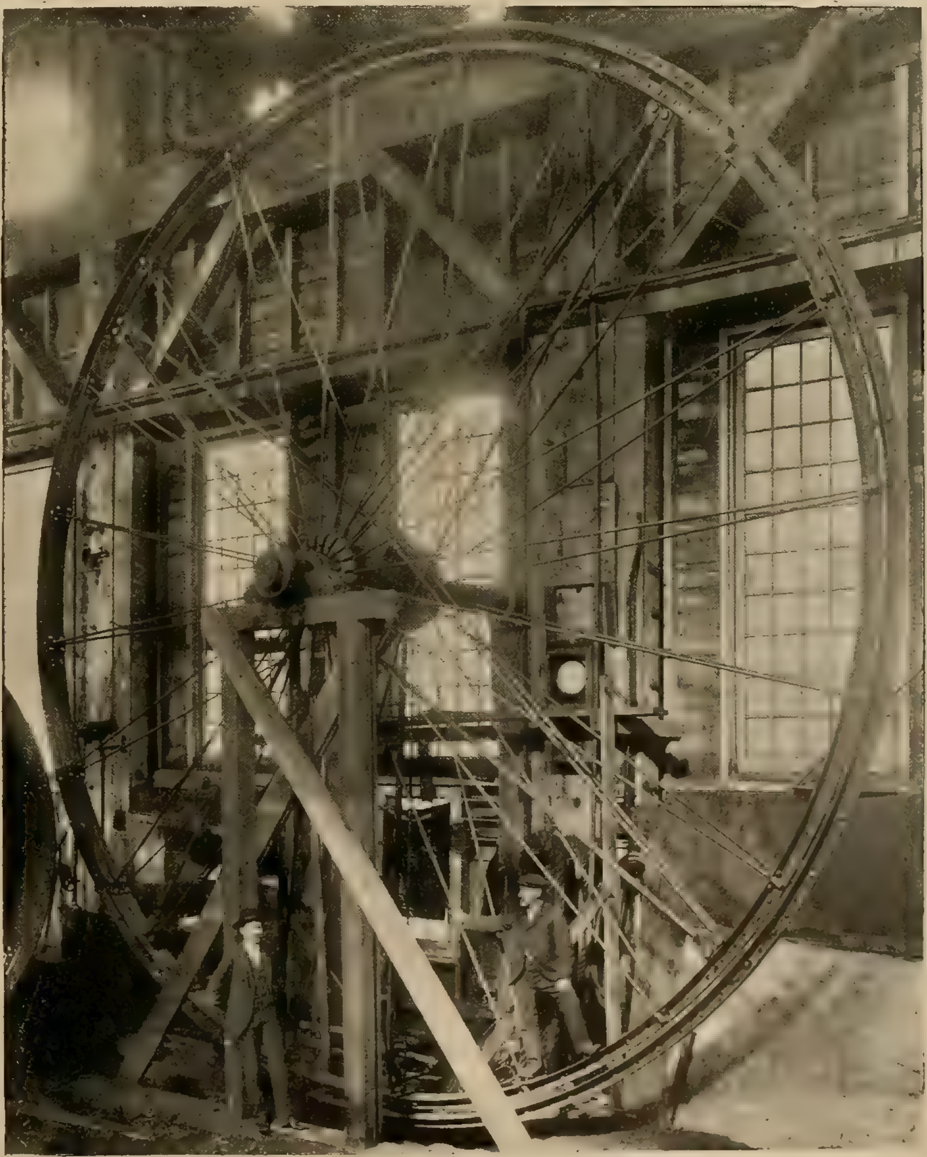
The new wheel, which is here illustrated as it appeared in the shops of the builders before shipment, is made entirely of steel except the hub, is 30 feet in diameter, and is to run at 65 revolutions per minute. It is designed to transmit 330 horse-power with one nozzle, or 1000 horse-power with three nozzles, each nozzle being 1¾ inches in diameter. The wheel operates under a head of 775 feet of water, and the power is transmitted from the rim to the hub and thence to the shaft which operates a duplex, single acting, compound air compressor. The wheel was constructed under the patent granted on August 14, 1896 to Edward S. Cobb, of the well known hydraulic and mechanical engineering firm of Cobb & Hesselmeyer.

There are several special features concerning this type of wheel that are of interest. It is perfectly adapted for use as a fly, gear, belt, or water wheel, and can be made to run any number of revolutions up to a rim velocity of 20,000 feet per minute. In the case of the present North Star wheel, the conditions required high peripheral speed, a slow number of revolutions and comparatively light total weight. This wheel was made of 4x4½-inch angle iron in four pieces for ease of transportation, and the shop test showed that it runs true within one-eighth of an inch at the rim without being turned in the lathe.

The principal dimensions of this new wheel, as well as those of the North Star wheel installed in 1895, are as follows:

	1895 Wheel	1898 Wheel
Diameter over all	18 feet	30 feet
Width of face	8 inches	9 inches
Diameter of shaft	10 inches	10 inches
Length of hub, bore	20 inches	39 inches
Length of hub over all	29 inches	48 inches
Center to center of spokes laterally at hub	24 inches	43 inches
Center to center of truss rods at hub	30 inches	36 inches
Diameter of radial spokes	1¼ inches	1⅛ inches
Diameter of truss rods	2 inches	1, 2 in. and 2, 1½ in. in each element.
Weight of rim	6800 lbs.	6000 lbs.
Weight of spokes	1500 lbs.	3000 lbs.
Weight of hub	2800 lbs.	4000 lbs.

It is stated on good authority that the cost of these wheels is very low when compared with that of other types, and the simplicity of their construction, ease of erection, and certainty of proper allowance for all stresses due to operation, make them safe and desirable wheels to use for any purpose whatever.



DIAMETER, THIRTY FEET THE COBB TRUSS WHEEL.

They can be designed for any weight or cross section of rim and of any diameter or number of revolutions per minute. The illustration shows many details of construction which vary with the weight of wheel desired, the power transmitted and the diameter, but above all will be impressed the striking boldness of engineering which the designer evidenced in order to increase the mechanical efficiency of the combination by eliminating the losses that result from the usual methods of reducing the speed of water wheels to that required for operating the air compressor, such as through gearing, belting or rope transmission.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

MINIATURE ARC LAMPS.

THE introduction of the enclosed arc lamp has extended the field of the arc system of electric lighting to interior illumination; the miniature arc of the General Electric Company promises another advance in providing for the use of arc light in smaller units so that it may compete with oil, gas, and incandescent lamps in illuminating halls, offices, display windows, and rooms of limited area.

Heretofore, arc lamps have been designed to give an intensely bright light, and they naturally required considerable current. For certain installations such lamps are not desirable. With low ceilinged rooms an intense light over-illuminates the arc directly beneath it, while other parts of the room are left comparatively dark. In the new minature arc lamps, the illuminating power and the current are much less, so that several lamps are not more expensive to operate than one large lamp; while by dividing the total amount of light required, the general illumination is greatly improved. The miniature arc lamp is also suitable for other places where a large arc lamp would supply more light than necessary. It is of the single globe and reflector type, the light of the arc being thrown down from the polished under surface of the reflector.

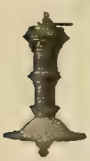


FIGURE 1.

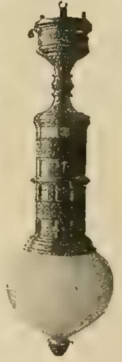


FIGURE 2.

This miniature arc lamp, designed for 110-volt, direct current circuits, is frequently required to operate at slightly higher or lower voltages. An adjustable resistance has, therefore, been provided in the top of the casing which adapts the lamp to any line voltage from 100 to 120. The standard current required by the GE. miniature arc lamp is 2½ amperes, but a loop in the magnet coil permits an adjustment for 3 amperes. 73 to 75 volts are required at the arc, and when adjusted for 2½ amperes with a line voltage of 110, the energy at the terminals is 275 watts. Adjusted for 3 amperes, the energy is 330 watts. The life is from 40 to 45 hours with standard current, and from 35 to 40 hours with 3 amperes. The mechanism of the miniature arc lamp operates on the well known General Electric carbon feed principle. The carbon is fed through a brass tube extending through the center of the magnet coil. The double cam clutch which operates directly upon the carbon is simple in its action and has few parts. Special attention has been given to the design of the carbon holders and the general arrangement of the frame to facilitate rapid trimming.

The principal dimensions of the miniature arc lamp are:

Length over all		18½ inches
Weight		9½ pounds
Upper carbon		8½x⅜ inches
Lower carbon		3½x⅜ inches
Enclosing globe, top diameter		2 inches
"	Maximum diameter	3 inches
"	Bottom diameter	$\frac{13}{16}$ inches
"	Height	4 inches
Porcelain shade		11x2x2⅝ inches

Figures 3 and 4 show the striking contrast between the size of the miniature lamps and that of a lamp sold for interior illumination a short time ago.

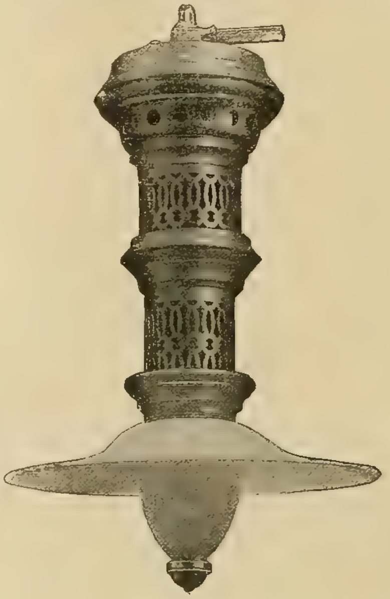


FIGURE 3.

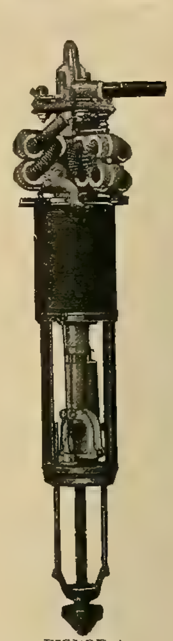


FIGURE 4.

No outer globe is used. Each lamp is arranged with a switch so that it can be readily thrown in or out of circuit.

Several hundred of these lamps have been introduced among central stations in the past sixty days, and there seems to be an increasing demand for arc lamps of small and attractive design.

MR. L. D. Tandy, of the engineering staff of the railway department of the General Electric Company, is in San Francisco and will probably remain on the Coast for several months.

TABLE OF CONTENTS.

Illustrated articles are designated by an asterisk (*); Editorials by a dagger (†); Passing Comment by a double dagger (‡), and Industrial by a section mark (§).

Illumination

*§ Miniature Arc Lamps 112

Hydraulics

* A Thirty-foot Impulse Water Wheel 111

Literature

‡ A Telephone Magazine at Last 1 6
Electricity in the Diagnosis and Treatment of Diseases of the Nose, Throat and Ear 1 8
‡ Riehle's Digest Suspends Temporarily 106

Mining

* Electricity in Mining—V 109

Personal

.... 107

Transmission

‡ Noteworthy Current Transformations 105
† Polyhase Current Distribution 104
‡ "Synchronous vs. Induction Motors" 106
The Ratios of Rotary Conversions 108
* The San Gabriel-Los Angeles Transmission, by Geo. P. Low 81
† The Snoqualmie Plant 104

THE JOURNAL OF ELECTRICITY.

VOLUME VI. SAN FRANCISCO, DECEMBER, 1898. NUMBER 6.

High-Voltage Power Transmission.[*]

BY CHAS. F. SCOTT.

SEVERAL years ago an investigation of the conditions and requirements incident to the use of high voltage was undertaken by the engineering department of the Westinghouse company. In this experimental investigation the size of the apparatus and the conditions of the test were, as far as practicable, such as would prevail in actual work.

The transformer, the *sine qua non* of high-voltage working, received first consideration. A design suitable for large sizes was worked out and tested; then high-voltage windings were made. Attention was next directed to the line insulator.

New phenomena were liable to be presented at higher voltages, and it was necessary to determine what they were, also how to meet the requirements which they impose. New forms and sizes of insulators were designed, made and tested to determine the losses which would occur and the limit at which they would break down.

The luminosity and the hissing sound emitted by the connecting wires of high voltage, suggested a loss which might be an appreciable addition to that over the surface of the insulators. It was found that a very considerable loss of energy took place between the wires—a loss which at high voltages was much in excess of that across the surafce of the insulators.

Mr. L. L. Nunn visited Pittsburg at this time and became much interested in this work. He was a pioneer in power transmission, having put in the first large alternating current transmission plant in this country, namely, that at Telluride, Colorado, which was designed by the writer and described by him[‡] at the General Meeting of this Institute in 1892. It was proposed that this work be taken up conjointly by the Westinghouse company and Mr. Nunn, and prosecuted on a much enlarged scale, by operating the original motor over a high-voltage line. Raising and lowering transformers were made and sent to Telluride, and power for the 100 H. P. synchronous motor was transmitted at voltages far exceeding any which had been previously used anywhere. Exceptional facilities were afforded for observing the practical operation of high-tension working under severe climatic conditions, and for making measurements. The results of the work were so assuring that the Telluride Power Transmission Company has lately installed a plant which is in commercial operation at 40,000 volts[†] and is now making an increase in the plant. This work has been continued on experimental circuits at East Pittsburg, and some measurements have been made at Niagara.

The work which has just been briefly described was an investigation into an unknown field. It has been progressively and systematically carried out and it has determined results which were unforeseen, and which are of both theoretical interest and practical importance.

This present paper describes the more interesting and important parts of this work and gives the methods by which measurements have been made and the results which have been reached. A number of points of interest and imporatnce are given with regard to long-distance transmission plants now in operation.

HIGH-TENSION TRANSFORMERS.

In 1891 the Westinghouse company furnished transformers for the 10,000-volt transmission to San Bernardino and Pomona. Twenty transformers were used in a set, each giving a pressure of 500 volts and the twenty in series 10,000 volts. This arrangement made the insulation within the individual coils a matter of comparative ease. The insulation between the coils of the high-tension circuit and other parts of the transformer was secured by allowing a space, which was filled with oil.

The first arrangement of transformers for giving from 30,000 to 50,000 volts was made by using a number of transformers, each giving 10,000 or 15,000 volts. The low-tension circuits of the several transformers received current from an insulating transformer in which there were a number of separate coils, each one supplying a separate raising transformer. An arrangement of this kind was used for obtaining the high voltages in the exhibit of the Westinghouse company at the World's Fair. A large transformer was designed in January, 1894. The output of 200 K. W. was many times greater than that of any transformers which had been made by the Westinghouse company. The transformer was oil-insulated and was cooled by water flowing through a pipe immersed in the oil. This transformer was pronounced a success, and the type was adopted and has been followed ever since as a standard, except that the water-cooling is employed only on the largest sizes.

The transformer was then rewound for 40,000 volts, and a somewhat reduced output. It was operated at this voltage for a short time, when it was found that, through an oversight, the insulation between layers was insufficient. In October the high-tension coils were rewound for 60,000 volts and the transformer is still in use, after many months of varied service and a considerable period of inactivity.

The making of a single large transformer for a very high voltage naturally involved new difficulties. Above 10,000 or 20,000 volts there was an unexplored and uncertain field in the matter of insulation. Materials which were commonly used at ordinary voltages might have very different characteristics under the new conditions. Tests were made on materials before the first high voltage transformers were made, and it has been continued. The large high-tension transformer as made to-day was not designed in a week or a month, but it has been an evolution based upon experimental tests and experience in continued operation.

HIGH TENSION INSULATORS.

After a high-voltage transformer was constructed, the insulator naturally presented itself as a fundamental factor in transmission. The requisites of an insulator for high-voltage work are, that it shall have a dielectric strength sufficient to prevent the current passing directly through the material, that its dimensions shall be large enough to prevent the passage of current over the outside of the insulator to its support, and that the resistance, both of the material and its surface, shall be sufficiently high to prevent undue loss of energy. In addition to these fundamental electrical requirements are those of a mechanical nature involving strength and convenience. These properties must of course be permanent, and not liable to deterioration while in service.

---

[*] Abstract of a paper presented at the Fifteenth General Meeting of the American Institute of Electrical Engineers, Omaha. June 30, 1898.

[‡] Transactions, American Institute of Electrical Engineers, Vol. IX, page 425.

[†] See THE JOURNAL OF ELECTRICITY, Volume V, page 169.

Up to this time very little attention had been given to the manufacture and design of high-tension insulators. There were available for our laboratory tests the glass insulators which we had designed for the 10,000-volt transmission line at San Bernardino and Pomona, California. (See paper of Mr. G. H. Winslow* before the General Meeting of the Institute in 1895.)

A much larger glass insulator was made having the so-called "helmet" form, which was probably the beginning of a type which is now quite common. The large glass insulator presented mechanical difficulties in manufacture, and recourse was had to porcelain. An insulator was designed to be underhung, the top of the insulator being suported in an inverted cup which was to be bolted to the under side of the cross-arm. From the bottom of the insulator a pin extended which was anchored in a hole in the insulator and held the wire several inches below the porcelain. The object was to place the wire below the cross-arm so that the snow which might pile up on the cross-arm would not come near the insulator. The wire, moreover, instead of being supported upon the top of the insulator, where it is in connection with an extended wet surface, would be supported from the part of the insulator which is most protected and the dryest.

An interesting evolution then began to take place in the manufacture of porcelain. There were eight or ten steps in this history, in which insulators which were presumed by the manufacturer to be satisfactory were broken down on high-voltage test. Porcelain which presented a beautiful, smooth, glazed surface was often found to contain internal cracks or cavities which were soon traversed by the current. In other cases bits of pebbles or other impurities were found. In still other cases the porcelain was not homogeneous and was not compact, or the material was porous and absorbed a drop of ink almost as readily as a lump of sugar would do. The effect of this work is seen in the improved quality of material now made by certain porcelan manufacturers who benefited by this experience. It may also be remarked that some of the unpleasant experiences with porcelain insulators might have been prevented if similar preliminary tests had been made instead of employing the more expensive and inconvenient method of testing them in commercial service.

The under-hung form of porcelain insulator, however, did not prove successful nor satisfactory. The insulator was heavy and cumbersome, and no satisfactory method was devised for holding the wire. A wooden pin lacks strength, and a metal pin reduces insulation. Moreover, smaller insulators of the ordinary form were found suitable for higher pressures than was anticipated.

Some measurements were made of the losses on the Pomona insulators. Twenty-four insulators were mounted on wooden pins. A wire was run along the tops of the insulators and a second wire connected the pins. The increase produced in the reading of a wattmeter in the primary of the raising transformer when the wires were connected to the high-voltage terminals was taken as the loss on the insulators. This loss at 25,000 volts was about two watts per insulator. This voltage between pin and wire corresponds to 50,000 volts between transmission wires.

LOSSES BETWEEN WIRES.

The loss over the surface of insulators was quite small, in fact almost insignificant compared with the amount of power which would ordinarily be transmitted. The various displays of energy about high-tension wires led us to investigate and determine whether this loss was one of importance. In order to measure the loss between wires, eliminating what occurs on the insulators, it was desirable to have a considerable length of wire, to suport it without insulators, and preferably to arrange the wires in such a form as to give a considerable loss. Nine wires, each 60 feet long, were stretched 4 inches apart in a horizontal plane and were held in place by strings several feet in length at each end. The wires were No. 19 B and S gauge, 0.036 inches in diameter. They could be connected in various ways, and any pair or pairs of wires could be omitted as desired.

The power supplied to the raising transformer was measured by a wattmeter placed in the primary low-tension circuit. When the load was placed on the transformer, the wattmeter reading increased, and the amount of increase was taken as the power delivered to the load. This method involves certain errors, which will be pointed out further on, but on the whole it gives an approximate and fairly correct indication of the power, and is sufficient to show clearly the general form of the loss curves and a number of interesting characteristics.

The first measurements of this loss are recorded Feb. 26, 1895. The 1st, 3rd, 5th, 7th and 9th wires were connected in multiple to one terminal, and the other wires were connected to the second terminal of the raising transformer; successively increasing voltages were applied.

The wires began to give a hissing or crackling sound and in the dark began to appear luminous at a little below 20,000 volts. As the voltage was increased the sound became more and more intense, the wires vibrated and became more and more luminous, until at the higher voltages they were surrounded by a coating of soft blue light many times the diameter of the wire. Often there were bright points along the wire, probably corresponding to bits of dust or rough places resembling points on the wire. The large room soon became strongly charged with ozone.

Results of measurements on all wires, alternate wires being connected together to one terminal, and the intermediate wires to the other terminal of the raising transformer, are given in the accompanying Fig. 1. Three curves are given for a frequency of 60 periods per second, or 7,200 alternations per minute. Two of these curves give the wattmeter readings for the different voltages, one for the transformer alone, and the other for the transformer and high-tension wires; the third curve gives the difference between the two, and therefore represents approximately the loss on the high-tension wires. Corresponding curves are given of tests made at a frequency of 133. The loss in the transformer is less at the higher frequency, but the loss on the high-tension wires is almost the same for both frequencies. These losses are very small below 18,000 volts, but increase rapidly up to 30,000 volts, which is about the highest pressure used.

As the two sets of tests were made with dynamos having different characteristics, they may not accurately represent the relative effects of the frequencies. The differences due to causes other than the frequency are, however, probably small, so that these tests are correct in showing the general relation between the loss and the pressure, and in indicating that the loss depends little, if at all, upon the frequency.

Tests were made with different numbers of wires. In one case the measurements were made with the arrangement described above, in which five wires were connected together and the four intermediate wires were connected to the second terminal of the raising transformer. Two wires at one end were then left off. Two of these were next omitted, leaving three connected to one terminal and two to the other. One of these was left off, leaving the 1st and 3rd wires connected together, and the 2nd and 4th also. The 1st and 9th wires were then connected together, also the 2nd and 8th. As the 1st and 2nd wire were well separated from the 8th and 9th, the mutual effect between them is negligible, so that the loss in this case may be considered as double that which would be obtained from the 1st and 2nd wires alone. The results of this measurement are plotted in Fig. 2. The points for both loss and current fall on a straight line and indicate that each additional wire causes a definite increase.

Measurements made upon wires at greater distances show that the action is considerably less as the wires are separated. The loss is approximately the same at 28,000 volts when the wires are 4 inches apart that it is at 36,000 volts when they are 16 inches apart. The loss for a distance of 8 inches is intermediate.

Other measurements were made, but nothing of further importance was developed. It is interesting to note that within a few days of the first measurements the general characteristics of this loss were determined, namely, that the loss between wires increases rapidly after a critical voltage is reached, that the loss is practically independent of the frequency, that it is much less as the distance between wires is increased. When a loss of 1,200 watts was obtained on a total length of 540 feet of wire at only 30,000 volts, the important bearing of this phenomenon upon transmission became very evident. The tests were stopped as preparations were begun for the continuation of the work at Telluride.

---

* Transactions, American Institute of Electrical Engineers, Vol. XII, page 405.

TRANSFORMERS AT TELLURIDE.

The original Telluride plants operated at 3,000 volts. Both the generator and the synchronous motor were wound for this pressure. Two transformers were furnished for the high-voltage tests, one for raising the generator voltage for transmission and the other for lowering the voltage for the motor.

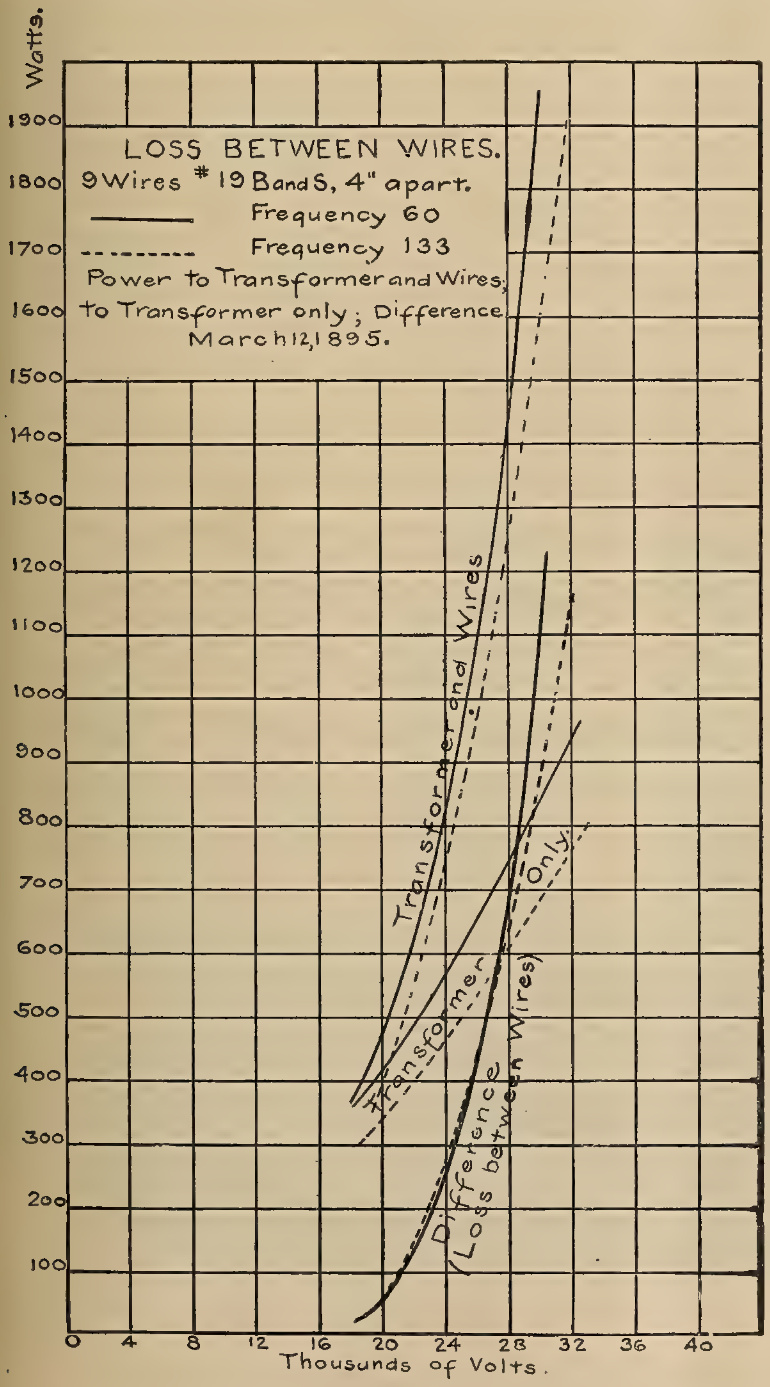


FIGURE I.

The windings were connected with a number of terminals by which the high-tension voltage could be varied over a wide range up to 60,000 volts.

Coils of similar shape were placed side by side in what is known as the "parallel" form of construction. Each coil had many layers of wire and but few turns per layer, thus securing a small difference of pressure between consecutive layers. The high-tension winding was divided into four similar coils, each designed to give a maximum of 15,000 volts. The individual coils could be differently connected, either in series or in multiple. The low-tension coils were five in number and were provided with loops, by which the number of effective turns could be varied. Three low-tension coils were placed between two pairs of high-tension coils and the two remaining low-tension coils were placed on the two ends. Between the low-tension and high-tension coils metallic shields were placed, which were connected to the ground for protecting the low-tension circuit from danger in case of accidental contact with the high-tension circuit, and also for screening the low-tension circuit from electrostatic induction from the high-tension windings. The transformer was immersed in a case containing oil. The iron and the case of the transformer, as well as the shields between the coils, were connected to the ground.

There was also an auxiliary transformer whose primary was connected across the generator terminals while its secondary was placed in series with the circuit to the raising transformer, thus either raising or lowering the generator E. M. F. as desired. The secondary had a number of steps so that the voltage could be varied at will.

THE TRANSMISSION LINE.

The line extends from the power station near Ames, which is a few miles from Telluride, Colorado, to the Gold King mill. The line passes over an exceedingly rugged country and has a total length of nearly 2¼ miles (11,720 feet). There are 62 poles, each carrying three cross-arms, the upper being about 26 feet from the ground. Each cross-arm carries two wires supported by insulators, which are designated as follows:—Large glass, small glass, parcelain. (See Figs. 4 and 5.) The large glass insulator is the same as that used on the circut in the San Bernardino and Pomona plant. The total height is 5 inches and the maximum diameter 5½ inches. The bottom of the insulator stands 1¼ inches above the cross-arm. The porcelain insulator is 4 1-16 inches high and 5⅞ inches in diameter. The bottom is 3 1-16 inches above the cross-arm. The small glass insulator is 3½ inches in height, 4¼ inches in ter. The bottom is 3 1-16 inches above the cross-arm. The insulator is triple petticoat; the other two insulators are double petticoat. The circuits were strung with galvanized iron wire 0.165 inches in diameter, which is No. 8 B. W. G., and about No. 6 B and S gauge. Later the circuit on porcelain insulators was changed to No. 6 B & S copper wire 0.162 inches in diameter. The measured resistance of one of the iron wire circuits was 66.25 ohms at —7 deg. C.

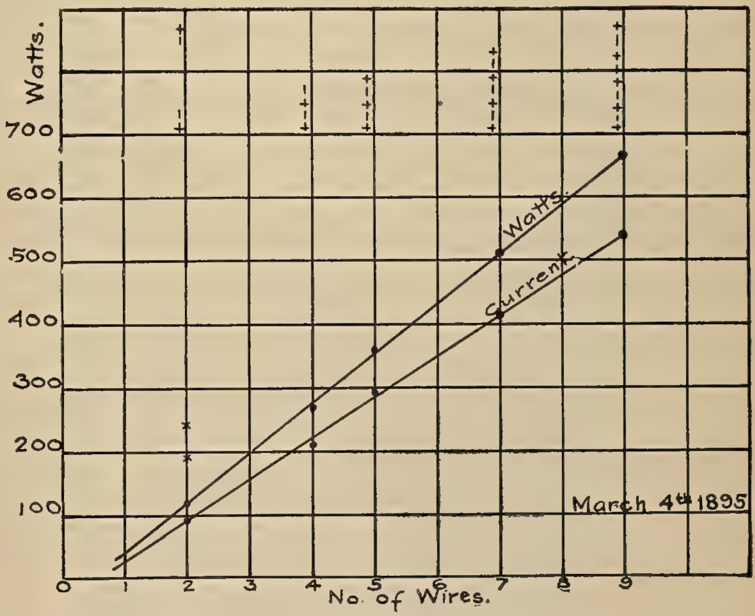


FIGURE 2.

THE LIGHTNING PROTECTION.

The lightning protection was laid out by Mr. A. J. Wurts, who previous to this time had spent some months at Telluride, determining the requirements for protecting the 3000-volt circuit. The protection consists of choke-coils and spark-gaps of non-arcing metal, as decribed by Mr. Wurts in his paper* before the Institute, March, 1892. In each line ten choke-coils were placed. Unit aresters, each consisting of seven non-arcing metal cylinders and having six spark-gaps, were connected as is shown in Fig. 3.

---

* Transactions, American Institute of Electrical Engineers, Vol. IX, page 102.

RUNNING TESTS.

The first tests were qualitative rather than quantitative. It was uncertain what phenomena might accompany the operation of a long line at high voltage, and the pressure which could be used on the insulators was a matter to be determined. The first thing was to find what would work; measurements could be made afterwards. A high voltage was placed on the transmission line, sometimes transmitting no power and at other times operating the 100 H. P. synchronous motor. In December, 1895, the motor was operated at 25,000 to 33,000 volts for several days. In January, 1896, 45,000 volts was used continuously for over a week, and beginning with the latter part of March a continuous run of 37 days was made at 50,000 volts. "Some very severe conditions of weather were encountered during this time, very high gales of wind prevailed, the air was filled with clouds of dust, part of the time the snow which fell was quite damp, and during the last few days of the run there was some rain. At this voltage the wires were plainly visible at night and the characteristic hissing of high-tension currents could be heard several hundred feet. No lightning arresters had been installed up to this time, and the cause of the shut-down was damage to the raising transformer caused by lightning. Lightning arresters were installed. The lightning season commenced about June 1st. During the latter part of June lightning discharges over the arresters were very frequent. At this time we were limited to a running voltage of about 34,000 volts, as there were not enough arresters to permit of increasing the voltage. No trouble whatever was had with the lightning protection. Discharges were frequently seen crossing the arresters, and during two or three days in the early part of the season discharges occurred at intervals of a few seconds for several hours. Enough arresters were afterwards obtained to run at 45,000 volts, but the lightning discharges were much less frequent."

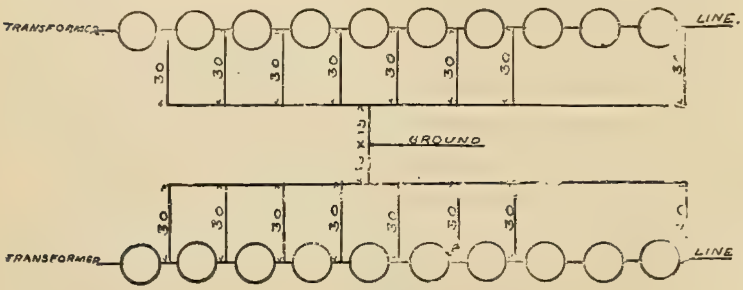


FIGURE 3.

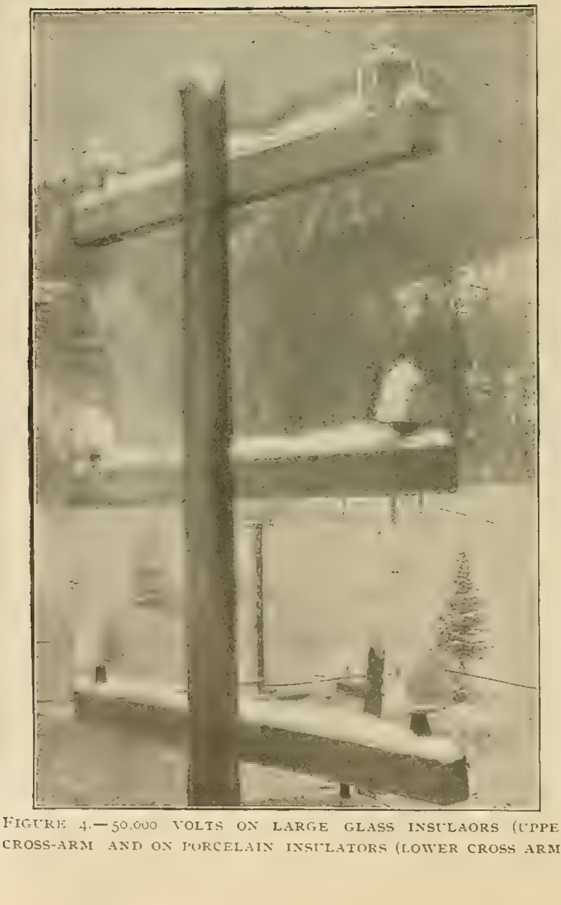


FIGURE 4.—50,000 VOLTS ON LARGE GLASS INSULAORS (UPPER CROSS-ARM AND ON PORCELAIN INSULATORS (LOWER CROSS ARM.)

Some measurements upon the line were made by determining the power to the raising transformers when the lines were connected and when they were disconnected. These measurements showed that the loss due to the line is small, below 45,000 volts, but increases rapidly when about 50,000 volts is exceeded, and reached 16.4 K. W. at 59,000 volts. The results up to 52,000 volts are given in curve 2, Fig. 9. Curve 1 in this figure is the loss on the same circuit measured a year later by a different observer using a different method. At the maximum loss shown there is a difference of only 8 or 9 per cent. in E. M. F. for the same loss on the two curves.

The record of the operation of this line at 50,000 volts for over a month is of very great interest, as it is a practical demonstration of the feasibility of operating a line at 50,000 volts, a pressure four or five times as great as any which had been in general commercial use. Mr. V. G. Converse had been up to this time closely associated with this work. He had much to do with the design and construction of the high-tension transformers and insulators, tests upon losses in lines made at the Pittsburg laboratory and the tests at Telluride.

MEASUREMENTS.

The work at Telluride was then taken up by Mr. R. D. Mershon. The facilities for experimental work were increased and instruments were provided for carrying on the tests. Mr. Mershon found peculiar difficulties in making exact measurements of the power to the circuit. A wattmeter in the low-tension circuit of the raising transformer led to errors under the conditions which prevailed. Some very able and painstaking work was displayed in detecting the error and overcoming it with the facilities at hand—and the facilities were none too plenty in the heart of the Rocky Mountains for making measurements which would tax the resources of almost any laboratory. The apparatus used introduced a disturbing influence in the circuit, which, however, could be measured and eliminated. On the other hand, a wattmeter for measuring power on a high-tension circuit must accommodate a very high voltage and a very small current. As the charging current to an open line is usually very large in proportion to the loss current, the error of the instrument is very sensitive to slight variations of phase in the shunt current. A description of the instruments and the methods used are given in an extract from the report of Mr. Mershon, which will be found at the end of this paper in Appendix A. The results of the measurements and the conclusions are given partly by extracts from Mr. Mershon's report, and partly in abstract.

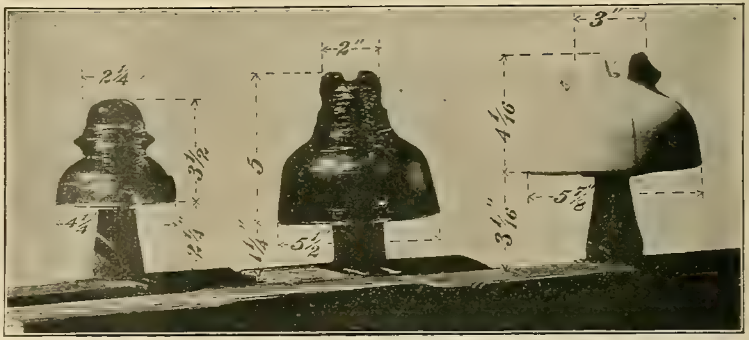


FIGURE 5.—INSULATORS USED IN HIGH TENSION TESTS AT TELLURIDE.

RESULTS OF MEASUREMENTS.

"The results of measurements taken are embodied in curves.

"In every case the measurements were taken upon an open-circuited line—in no case upon a line which was transmitting power. The line losses obtained are, therefore, a combination of those occurring between the line wires and the very small $I^2 R$ loss in the wire itself due to the charging current of the line.

"Measurements taken with the Weston wattmeter include

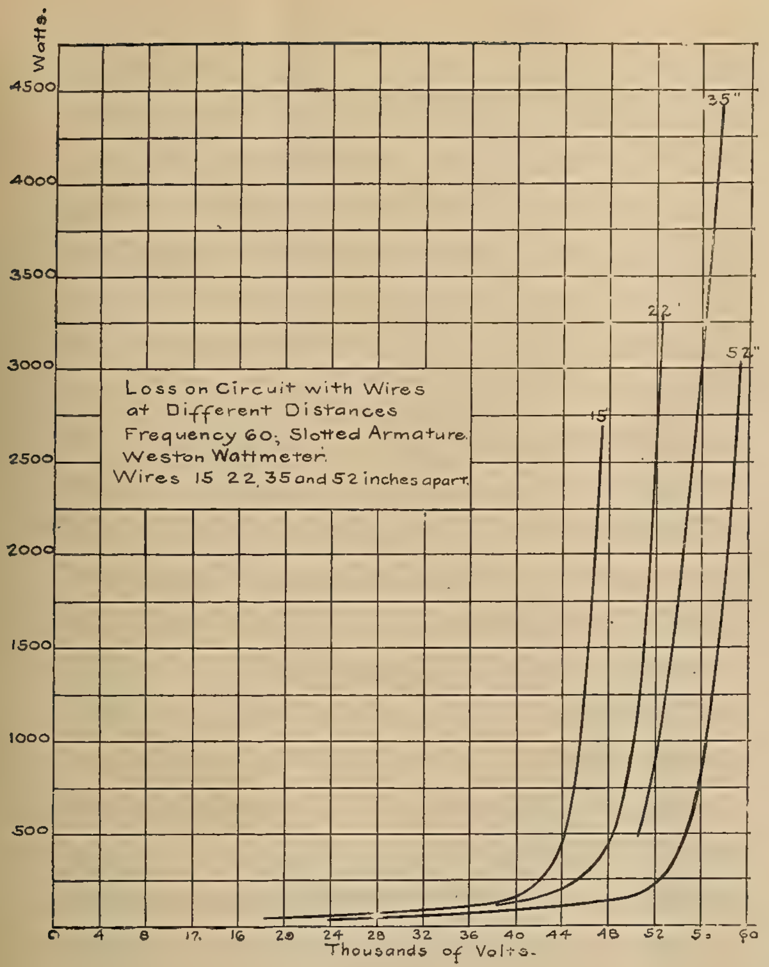


FIGURE 6.

the loss in the high-tension coil of the power transformer due to the currents applied to the line. This loss is in general small, and in the following curves corrections have not been made for it. Curves taken with the Thomson wattmeter require no such correction.

"There is an additional correction which may be made in the case of those curves whose voltage were obtained from the raising transformer. This correction arises from the fact that the action of the capacity current taken by the line, in connection with the series reactance of the transformer supplying it is such as to make the voltage impressed upon the line somewhat greater than that obtained by the ratio of the transformer winding. The measurements taken to determine the amount of the error in voltage show it to be small.

"There were two generators used. One was that regularly running and supplying power to the power circuits of the Telluride Power Transmission Company. It is a 600 K. W., 22-pole, quarter-phase machine, delivering 500 volts at a frequency of 60, or 7,200 alternations per minute. Its armature is of the slotted type and is wound with copper bars. In the notes this generator is designated as 'Slotted Armature.'

"The other generator is one whose field is that of the 100 K. W. toothed armature machine, originally sent out as a part of the first Gold King transmission plant. It has twelve poles, and as originally run operated at 3,000 volts and 10,000 alternations. There are two armatures for this machine—a surface-wound armature, designated as 'Smooth Armature,' and a toothed armature, designated as 'Toothed Armature.' "

COMPARISON BETWEEN INSULATORS.

A set of measurements was made for comparing the loss on the three circuits supplied respectively with large glass, small glass and porcelain insulators. The curves are very nearly identical and corespond very closely with the right hand curve in Fig. 6. "There was a heavy, wet snow on the ground and the cross-arms at the generating station, and more or less snow all along the line; that at the further end being drier than at the generating station. There was more or less snow falling during the measurements, and this accounts for a wide variation of the points taken at the high voltages, as falling snow renders the wattmeter reading very unsteady, the unsteadiness being such as one might expect if from time to time there was a discharge between the wires. This unsteadiness does not seem to be as great in the case of falling rain as in the case of falling snow."

LOSS AND SEPARATION OF WIRES.

A series of measurements was made to determine the connection between the loss and the distance between wires. "As at that time it had not been fully demonstrated that the loss was not affected by weather conditions except there was precipitation, changes in distance between wires were made upon one circuit, while the distance between wires on another circuit was maintained always the same, and the latter was used as a reference circuit when a change in loss was obdinate."

The several curves have been plotted together, due correction being made for the slight difference in the loss in the reference circuit, which probably resulted from slight differences in the precipitation when the curves were taken. The distance between the wires in the several tests was 15, 22, 35 and 52 inches, respectively. The results are shown in Fig 6. It will be noted that the loss is much greater when the wires are close together and that the curve begins to ascend at a lower voltage.

COMPARISON OF WATTMETERS.

The loss curves in Fig. 7 were taken on one of the circuits, first with the Weston wattmeter and then with the Thomson wattmeter. The Weston wattmeter was not in circuit when the measurements with the Thomson wattmeter were taken. As an additional check, the readings were taken on each of the wattmeters of the loss occurring in the shunt resistance; of the Thomson wattmeter the results were in practical agreement with each other and with those obtained by calculation. The discrepancy in the results obtained on the two instruments when measuring line loss will be referred to later.

LOSS ON INSULATORS.

A set of comparative readings was taken on one of the circuits and on a dummy circuit, identical with the main circuit, as regards kind and number of insulators and the size of wire, but only 60 instead of 11,720 feet in length. The results show that the loss on the two circuits is practically identical up to about 50,000 volts, which is the part of the curve below the bend. The losses agree closely with those shown in Fig. 6. At higher voltages the loss on the dummy circuit increased slightly, indicating that the loss was of the same nature as that at a lower voltage. The agreement of the loss on the two lines at low voltage (*i. e.*, below the bend in the loss curve) indicates

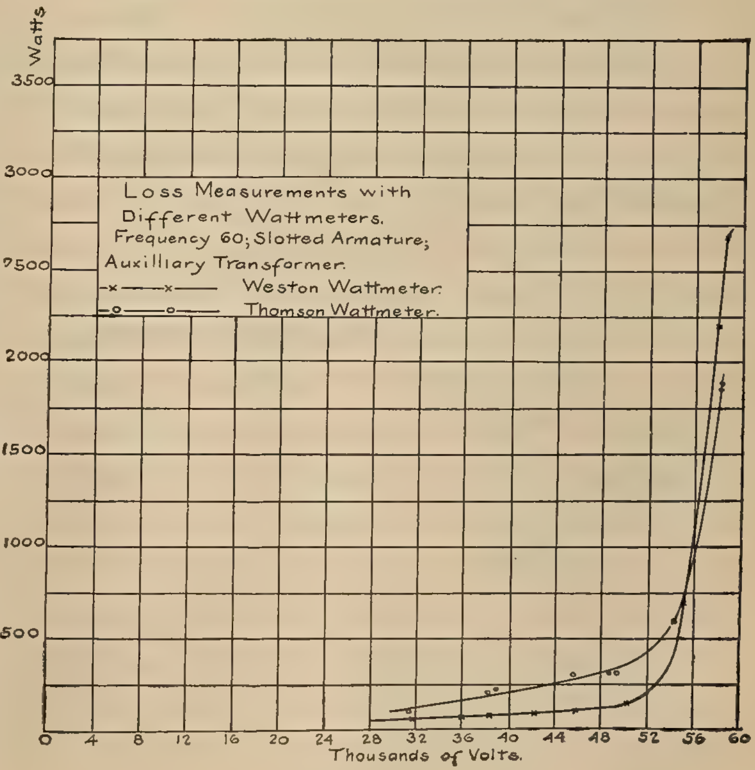


FIGURE 7.

that this loss was over the insulators. The great increase in loss on the long line at high voltage indicates that the loss was due, not to the insulator, but to the line.

RESISTANCE AND REACTANCE.

Measurements were made with resistance between the generator and the raising transformer, then with reactance and then with neither resistance nor reactance. The results are shown in Fig. 8, and indicate a different condition, depending upon the character of the circuit supplying the current. It was presumed that this difference arose from a modification of wave form of the E. M. F. applied to the line.

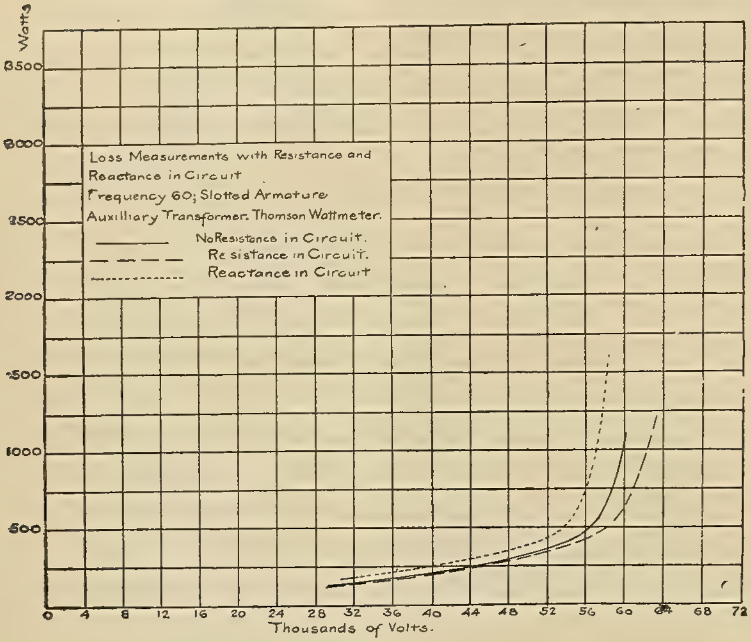


FIGURE 8.

WAVE FORM AND LOSS.

Measurements were made upon the wave form and the corresponding losses when different generators were used and different circuits were connected. In one test an armature giving nearly a sine wave was used which delivered current at 30 cycles. Measurements were made upon one circuit only, and then upon two circuits in multiple. The current and the loss are both given in Fig. 9. The wave form for no load and for both conditions of load are given in Fig. 10. The current taken by the two circuits in multiple is twice that to a single circuit. The variation from a straight line in one of the currents curves is due to a change in wave form as the voltage is increased.. The loss for the two circuits in multiple is about twice as great as for one circuit at low voltages, but it is less than that for one circuit at high voltages. Referring now to the wave form taken at high voltage, it is seen that the wave form for the two circuits in multiple has a lower maximum than that for one circuit alone. The reduced loss on the two circuits is undoubtedly due to the different wave form when both circuits were connected. The distortion of the wave form is due to the reaction which the leading current produces in the generator and transforming apparatus.

Wave forms were also taken on the slotted armature giving 60 cycles. The wave forms are given in Fig. 11. The conditions are similar to those just described, in that a single circuit produces a wave having a much higher maximum than that produced when two circuits are run in multiple. The losses (which are not shown) bear the same general relation as that in the last case, namely, the loss with two circuits is greater at low voltage and at the high voltage is less than that on a single circuit.

A wave form was taken upon the toothed armature both at no load and when supplying current to one of the circuits. These are shown on Fig. 12. This wave differs radically from a sine wave at no load and is greatly distorted when supplying a leading current. In the no-load wave the value of the fundamental is 72.5 per cent.; the third harmonic, 21.6 per cent.; the fifth harmonic, 4.8 per cent. The corresponding loss is given in Curve 1, Fig. 9. The distorted wave makes the Thomson wattmeter read too high, especially at the lower E. M. F'S.

OTHER OBSERVATIONS AND TESTS.

"A series of observations were taken, extending over a period of thirty-three days, to determine whether there was any connection between the loss occurring on the lines and the variations in weather conditions. Three readings were taken each day. They were, in addition to the wattmeter readings, readings for barometric pressure, temperature, humidity, wind direction and wind velocity. The weather observations were taken simultaneously at Ames and the King, using sets of weather instruments furnished by the United States Weather Bureau, and if there was any variation in the loss on the lines for the observed range of weather conditions, it was so small as to be inappreciable. The results of all measurements taken during this work seem to confirm the fact that the only weather conditions whatsoever which affect the loss to any practical extent is that of precipitation. The loss seems to bear some relation to the size of the particles precipitated, being greater for a fall of snow in which the flakes are large than one in which the flakes are small.

"In the power transformers used, the series reactance was comparatively small because of the subdivision of the coils. A change in the condition on the line as regards loss occurred when the Weston wattmeter was placed in circuit. This was detected by measurement upon the Thomson wattmeter, both when the Weston wattmeter was in circuit and when it was not. Moreover, the lines hissed when the voltage is 55,500 and the Weston wattmeter is out of circuit, but when the Weston wattmeter is thrown into circuit the hissing ceases, although the voltage rises to 57,700. The hissing sound is a characteristic of high-voltage lines and begins at the bend in the loss curves. It always accompanies luminosity of the lines.

"Along with this change there was another phenomenon not previously mentioned. This was a discharge which took place from time to time between the terminals of individual choke-coils. The discharge would occur sometimes between the terminals of one choke-coil and sometimes simultaneously on two or three of the choke-coils. These discharges made considerable noise, sounding very much like a pistol shot, and could be heard at a considerable distance from the transformer house. As the choke-coil terminals are distant from each other about 8¼ inches, it is not thought that this discharge took place through the air, but over the surface of the wood enclosing the choke-coil. This discharge, however, left no mark on the surface. Simultaneous with these choke-coil discharges one could hear, if standing under the line some little distance from the transformer house, a slight snap, which seemed to be a phenomenon rather of the whole line than of any particular spot in it. Sometimes there was a corresponding snap over the lightning arresters. As the lightning ar-

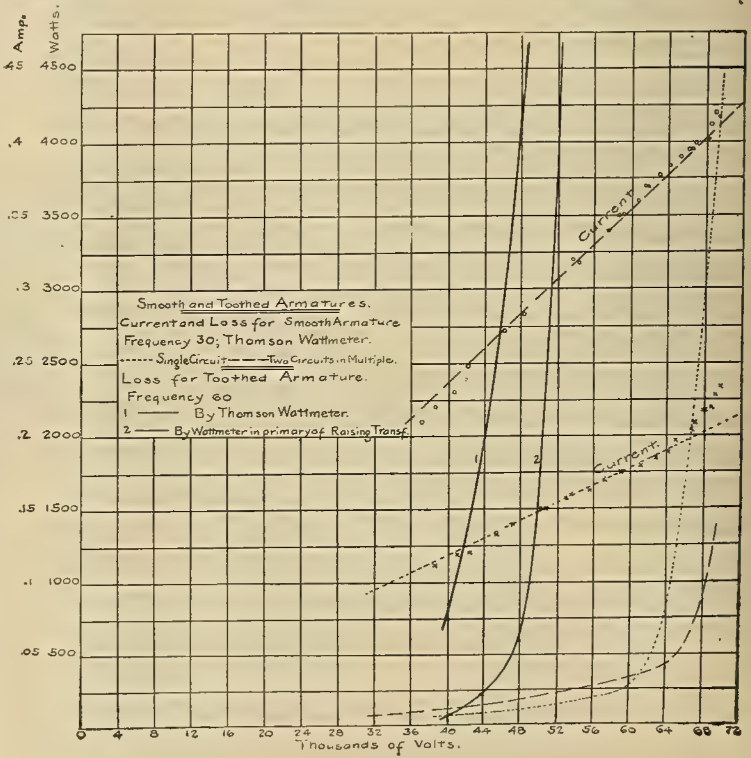


FIGURE 9.

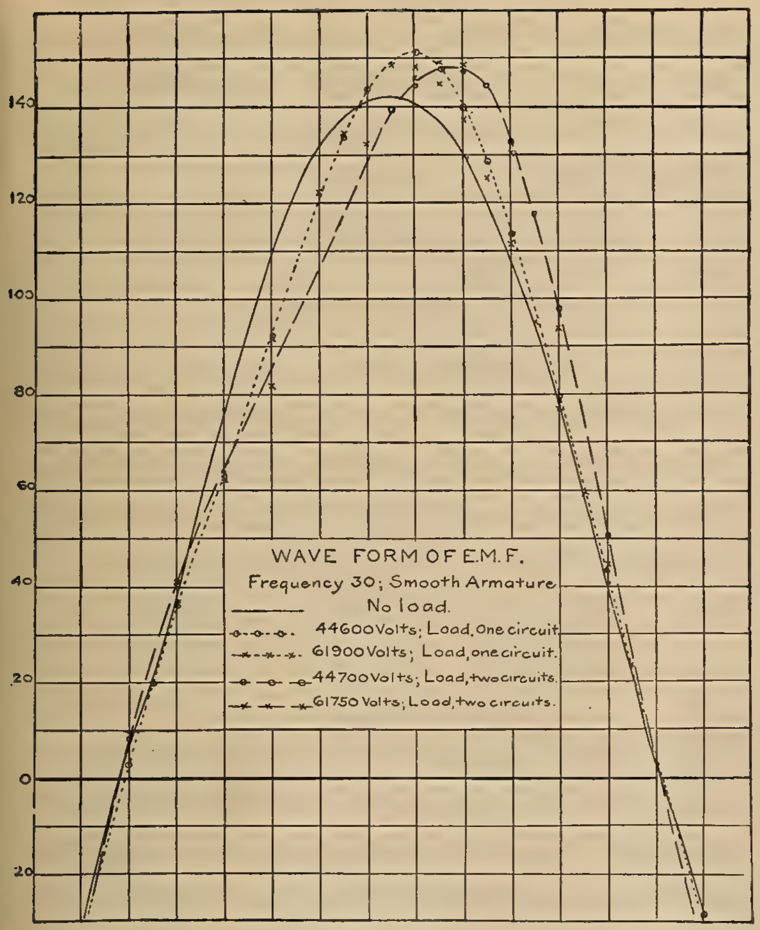


FIGURE 10.

resters make more or less noise at all voltages, this snap over them may have been present at all times, but in some cases not sufficiently well marked to be heard above the continued hissing of the lightning arresters.

"After the preceding results had been obtained, the two power transformers were connected up with their high-tension windings in series, the point of connection between them being grounded, and with their low-tension windings in multiple. With this arrangement voltage was impressed on one of the circuits, power being supplied by the smooth armature at 7,200 alternations. The voltage was run by means of the machine field to 90,000.

"As the power taken by the lines at this voltage overloaded the motor used to drive the generator, a span was cut out of the circuits at a little distance from the station, leaving about 500 feet of wire in them. The voltage was run up to 133,000 volts and held there for some minutes; but the current finally jumped from the outside terminal of each transformer to the iron, smashing the heavy glass tube with which these terminals were insulated."

The following is taken from Mr. Mershon's discussion of the results of his tests:

"There is evidently a certain critical voltage at which the loss occurring between wires begins to increase very rapidly; indeed, it seems as though there might be something of the nature of a polarization similar to that which occurs in the case of an electrolyte; that there is something of this nature in the case of air or other gases subjected to an electrostatic stress is well known, and it has been taken as an explanation of the fact, that in the experimental determination of sparking distances in air, a certain minimum potential is necessary to establish an arc, no matter how small be the sparking distance. Also, Varley has done some work on tubes containing gases. This work was done with a series of Daniell's cells yielding 300 to 400 volts. The voltage was impressed upon electrodes sealed into the tubes. He established the following facts:—First, that each tube required a certain potential to leap across; second, that the passage for the current having been once established, a lower potential was sufficient to continue the current; third, if the minimum potential which would maintain a current through the tube be P and the voltage varied to P plus 1, P plus 2, etc., to P plus N, the current will vary in strength as 1, 2, 3, etc., N; P always meaning the lowest value at which the current will continue, and is less then that at which the current starts.

"If such a condition of affairs obtains in this case, the loss curves of the preceding sheets must be made up in two parts, one the loss over the insulators and cross-arms, the other the loss occurring through the air. The first part of the loss curve up to or near the point where the abrupt bend begins, must be the loss over the insulators and cross-arms alone; beyond the point where such a bending occurs, the loss curve must be made up of a combination of the two losses referred to.

"If the action which takes place in air is similar to that obtained by Varley, we might expect that both (1) the position of the critical bend on the loss curve and (2) the law which the loss follows above the bend, would be affected by the former of the E. M. F. wave impressed upon the line, for the former (1) must depend, not upon the mean square of the voltage impressed upon the line, but upon the mean square of that portion of the E. M. F. wave which is above a certain critical voltage, and the latter (2) must depend upon the form of that portion of the E. M. F. wave above a certain critical voltage because, as Varley shows, the minimum voltage at which this peculiar loss begins differs slightly from the minimum voltage at which it will continue after the action has been established. If it were not for the latter consideration it would be comparatively easy to determine the equation for such loss at least in the case of a pure sine wave, and it might be that there is a sufficiently small difference between the voltage at which this loss will begin and the voltage at which it will discontinue for such an equation to hold practically. That the loss depends upon the maximum value, if not upon the form of the E. M. F. wave, is shown by several of the loss curves in connection with their corresponding wave forms. This is particularly notice-

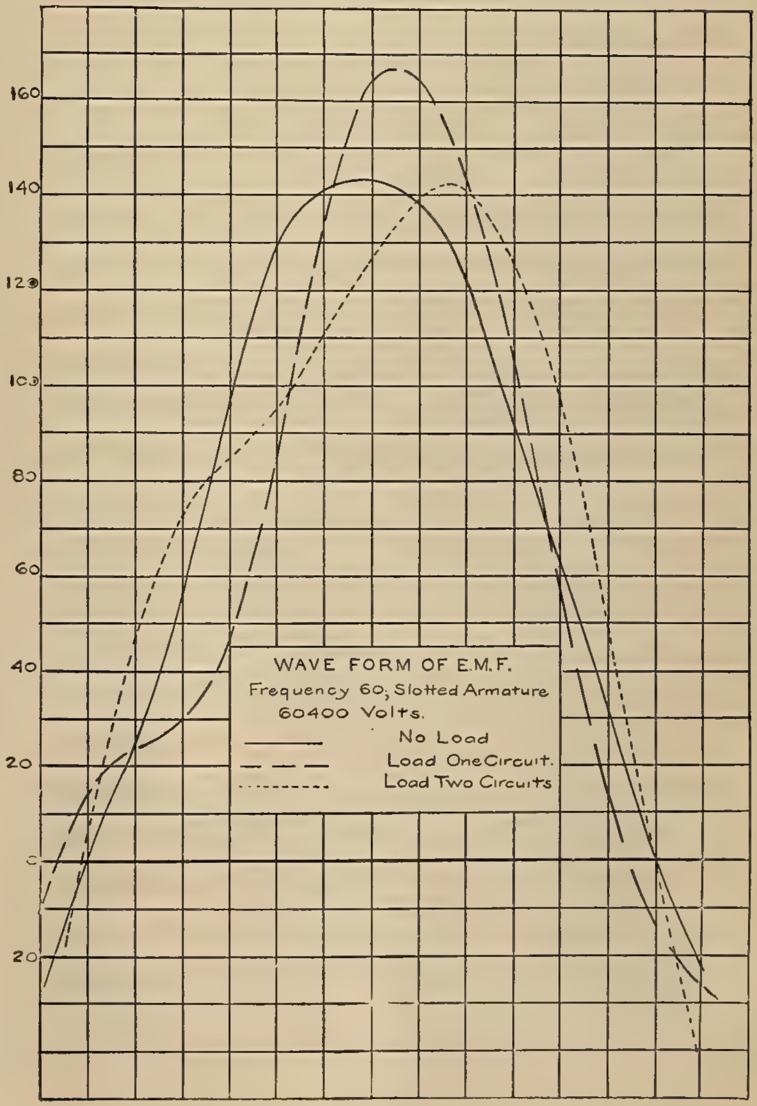


FIGURE 11.

able in one or two cases where the loss on two lines in multiple is less than that on one line, and although some of these comparisons will have to be made between curves taken on the two different wattmeters and are, therefore, not strictly comparable, they may be compared after such corrections as is mentioned below in discussing the wattmeters. In any case, the curves are comparable, qualitatively, as regards the position of the critical point.

"It might be objected that the results are rendered questionable by the curves in Fig. 7. The curves were taken under presumably similar conditions, except that one was obtained by means of the Thomson wattmeter and the other by means of the Weston wattmeter. This discrepancy is attributed to a charging current passing through the shunt resistance of the Thomson wattmeter. That the amount of capacity current necessary to produce the discrepancy is small, appears upon the following considerations:—In one case the loss obtained upon a circuit at 38,000 volts when using the Weston wattmeter is 90 watts, and under the same conditions, but using the Thomson wattmeter at 38,000 volts a reading of 9,500 watts; the loss obtained by the two wattmeters is, therefore, 125 watts. The current is about 0.25 of an ampere. Now, 0.25 of an ampere, if in step with the E. M. F., would give on the Thomson wattmeter at 38,000 volts a reading of 9500 watts; therefore the capacity current through the shunt resistance necessary to produce the discrepancy of 125 watts is 125 divided by 9,500, or about 1.3 per cent. of the current in the shunt resistance. The shunt resistance has a value of 1,202,300 ohms; at 38,000 volts the current through it would be about 0.032 amperes; 1.3 per cent. of this, or 0.00416 amperes, is that required to produce the discrepancy noted. In further support of this method of accounting for the discrepancy, the results obtained at different numbers of alternation using the Thomson wattmeter show a variation for different numbers of alternations of the losses below the bend in the loss curve, and which are thought to occur over insulators and cross-arms. There should be no variation in such loss for a variation in frequency.

"Any discrepancy occurring in the Thomson wattmeter by reason of a capacity current in its shunt resistance will be affected to a greater or less extent by change in the wave form.

"It is believed that all the phenomena connected with this work may be studied in a tube which has been partly exhausted. The work could then be done with comparatively low voltage and using direct current, which would much simplify the measurements. The contents of the tube might be partially rarefied air or other gas, as the action would undoubtedly be similar in all cases. With such a tube might be studied the law of variation in distance and form of electrodes, also in material and surface of the same.

RESUME AND CONCLUSIONS.

"It is undoubtedly true that the loss is made up of a loss over insulators and a loss between wires, and that the latter is the only loss worth considering.

"The loss between wires is not affected by any atmospheric conditions except precipitation. This statement, of course, must be taken as applying to such a climate as that in which the measurements were taken. The lines were seldom in fogs or clouds, and when they were, or when rain was falling, the moisture was of the purest. Near cities the loss would be undoubtedly much greater than that shown in these curves, because of the impurities both in solution in the moisture of the atmosphere and in supsension.

"There will be for a given transmission a certain economical voltage, because while an increased voltage, with a given line wire, will reduce the loss in this wire by decreasing the transmission current, it will also increase the loss between the wires.

"It is believed that attention to wave form is very important. The sine wave is undoubtedly the best as giving a stable form, and because of superior results with all kinds of apparatus. A flat wave would of course give less loss, but would not be stable, and as the nearest practicable approach to a sine wave will not be perfectly stable but will still contain some harmonics, it will be of advantage to keep the series reactance of the transformers and generators as low as possible.

"It is believed that 40,000 volts is perfectly conservative and safe as regards loss between wires for any ordinarily good wave form, and in a climate such as that in which the measurements were taken, *i. e.*, where the air and precipitated moisture are practically pure, 40,000 volts comes well below the bend in the loss curve even under the worst weather conditions.

"I can see no advantage of porcelain over glass, unless it be that of superior mechanical strength. The latter is rather a doubtful advantage. The ball from a heavy calibre rifle or revolver such as are used in the western country will smash any insulator, whether glass or porcelain. Porcelain offers a more tempting mark, being white. As to hygroscopic properties, no difference could be discovered so far as these measurements were concerned. It will make little difference under running conditions whether the insulator be hygroscopic or not, as the small amount of power necessary to keep the surfaces dry will be insignificant. I say under running conditions, because in starting up a 'cold' line there is danger of breakdown if current is put on suddenly at full value, instead of being raised gradually. As far as the resistance to piercing is concerned, glass is just as good practically at least as porcelain. It needs no electrical test to pick out a good glass insulator, which is one advantage of glass over porcelain.

"To sum up, glass insulators are cheaper, lighter, more easily tested and less likely to be shot at than procelain; on the other hand, they have less mechanical strength.

"In every case, in my experience, where a break-down has occurred, it has been on a cross-arm which was 'wind shaken' and 'weather cracked,' the current following the cracks. This leads to a curious result. The mark of the current will be on the surface of the arm for five ar six inches, then disappear from the surface altogether for some inches, then reappear, etc. On cutting open the arm one sees how the current has followed the best path, dodging in and out. Rain and moisture probably settle towards the cracks, carrying salts from the body and surface of the wood. This forms a path of low resistance, especialy in wet weather. For this reason I have in the plant of the Colorado Electric Power Company taken particular pains in treating both pins and cross-arms. The cross-arm treatment is such as fills all cracks and fissures as a section of the wood shows.

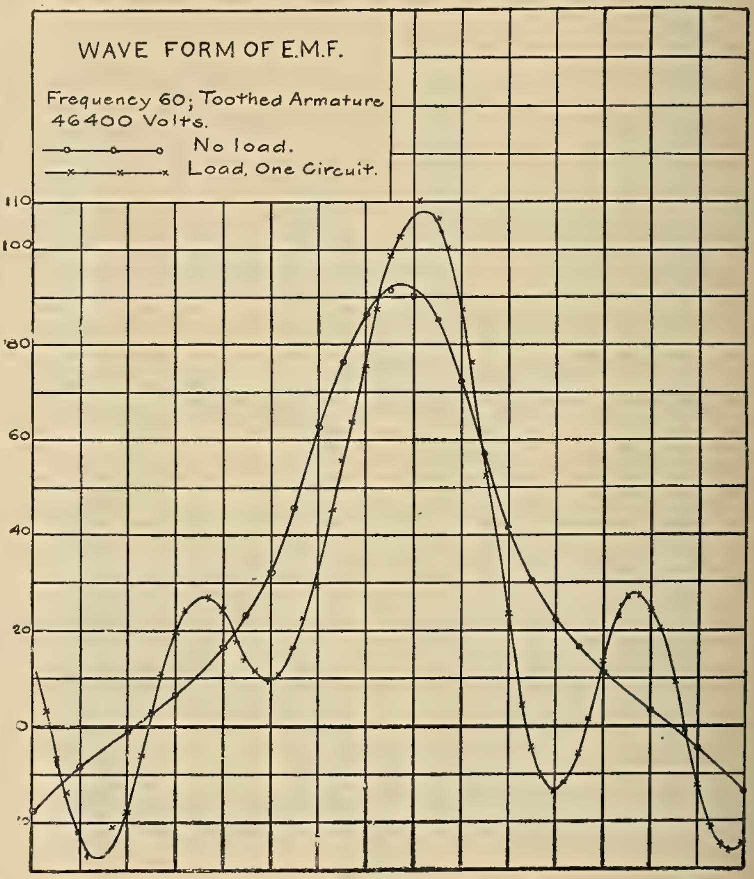


FIGURE 12.

"This report would be incomplete without an acknowledgment of the assistance rendered in the work by the engineering force of the Telluride Power Transmission Company, headed by Mr. P. N. Nunn. Especial credit should be given Mr. A. L. Woodhouse for his faithful work and constant perseverance in the face of great discouragement."

FURTHER HIGH-TENSION TESTS.

Laboratory tests and measurements on a small scale cannot take the place of tests under the conditions of practical service, such as those at Telluride. There are, however, many important elements which may be determined by laboratory measurements.

A high-tension line for testing insulators and making measurements upon the losses between wires was erected at the East Pittsburg factory in the fall of 1897. A number of the tests which have been made are here recorded.

(1) A test was made to determine whether the wave form of the charging current to the line was similar to that through a resistance, or whether it was modified by the loss component, the loss occurring only at the higher part of the E. M. F. wave. The current to the high-voltage line, at pressures varying from 30,000 to 60,000 volts, was passed through a coil possessing high self-induction. The E. M. F. upon the coil was measured by a voltmeter. The E. M. F. was also measured when a current of equal strength was passed through the coil, the line being short-circuited and a low E. M. F. applied. It was found that the voltage upon the coil was the same, within a small error of observation, in both cases, showing practically no difference in the wave form of the current under the two conditions. The current was from an armature giving practically a sine wave.

(2) The charging current to the line was measured under several different conditions when the current was obtained from a generator giving practically a sine wave. The results of measurements were compared with the currents as calculated by the theoretical formula. The last measurement in the table was made upon the Niagara-Buffalo line, with current from a Niagara generator, which differs slightly from a sine wave.

COMPARISON OF MEASURED AND CALCULATED CHARGING CURRENT TO PARALLEL WIRES. LENGTH, ONE MILE—10,000 VOLTS.

Size of Wire	Distance Between Wires	Frequency	Measured Amperes	Calculated Amperes
No. 8 B. & S.	21.7 inches	60	.0307	.028
8 B. & S.	48.0 inches	60	.0245	.0252
8 B. & S.	79.5 inches	60	.0234	.0238
8 B. & S.	127.5 inches	60	.0225	.0242
No. 8 and ground	120.0 inches	60	.0427	.0412
0.71 in. diameter	18 in for ⅔ of distance 36 " ⅓ " "	25	.0176	.0176

(3) The fall of potential around the wires was noted by tests made with spark-gaps. The wires 48 inches apart were connected to the high-voltage terminals and a spark-gap was placed between two idle wires, also 48 inches apart, placed about 21 inches below the first wires. A spark-gap consisting of brass terminals with a ¼-inch radius was placed between the two idle wires. When the gap was 1-32 inches the spark began when the E. M. F. from the raising transformer was 26,000 volts. A gap of 1-32 inches requires an E. M. F. of 2,200 volts to produce sparking. When the spark-gap was made 8-32 inches (equivalent to 12,000 volts) the sparking began at 103,000 volts from the raising transformer. At intermediate points there is a fair proportionality between the spark-gap and the E. M. F.

In another test a spark-gap was placed between one of the idle wires and the adjacent wire of the live circuit. When the spark-gap was ⅛-inch (equivalent to 6,000 volts) the spark passed when the E. M. F. was 17,500 volts, and when the spark was made ¼-inch (equivalent to 12,000 volts) the sparking began at 33,000 volts. When the gap was ⅜-inch (equivalent to 16,000 volts) sparking began at 41,000 volts. When the gap was ½-inch (equivalent to 20,000 volts) sparking occurred at 49,000 volts. The E. M. F. did not differ greatly from a sine wave. These tests have an important bearing in connection with the running of telephone and other circuits adjacent to high-potential wires. It is essential that the wires of a high-potential circuit be spiralled so that each wire sustains the same relation as every other wire to the second circuit, in order that the effects of static induction may be neutralized.

(4) The effect of the size of wire upon the loss was investigated by running a pair of No. 28 brass wires 126 mils in diameter, and then replacing it by large rubber-covered wires. The rubber-covered wire was No. 7 B & S gauge, 144 mils in diameter; the outside diameter of the rubber covering was 300 mils and the diameter over the braid was 350 mils. Measurements were made upon another circuit which was unchanged during the different tests, and thus served for comparison. The results of these tests are shown in Fig. 13, which also gives the conditions when one fine wire and one wire of larger size, No. 8 B & S, constituted the circuit. This comparison shows the very marked increase in loss when the fine wire is used. The loss on the rubber-covered wire, however, increased considerably after the voltage had been raised and the rubber had broken down, thus permitting the current to pass freely to the outer surface of the insulation. It is quite probable that the loss would increase as the insulation became defective, until it was nearly equal to that of a wire having the same total diameter.

The measurements on wires of different sizes given in Fig. 13 are qualitatively correct, although some of the readings on which the curves are based were quite small, so that the absolute values may not be exact.

(5) The effect of the current in drying the surface of the insulators was illustrated in a test made during a rain. Upon applying 45,000 volts to a circuit the wattmeter indicated 116. After four minutes the deflection had decreased to 72, the current remaining the same. The E. M. F. was then increased to 60,000 volts, the wattmeter deflection increased to 155, and at the end of three minutes it had fallen to 138. The current was one-third greater than at the lower voltage, but remained constant while the wattmeter changed. The rain continued during the test, which shows, therefore, that the condition of the insulator is materially improved by the presence of the current.

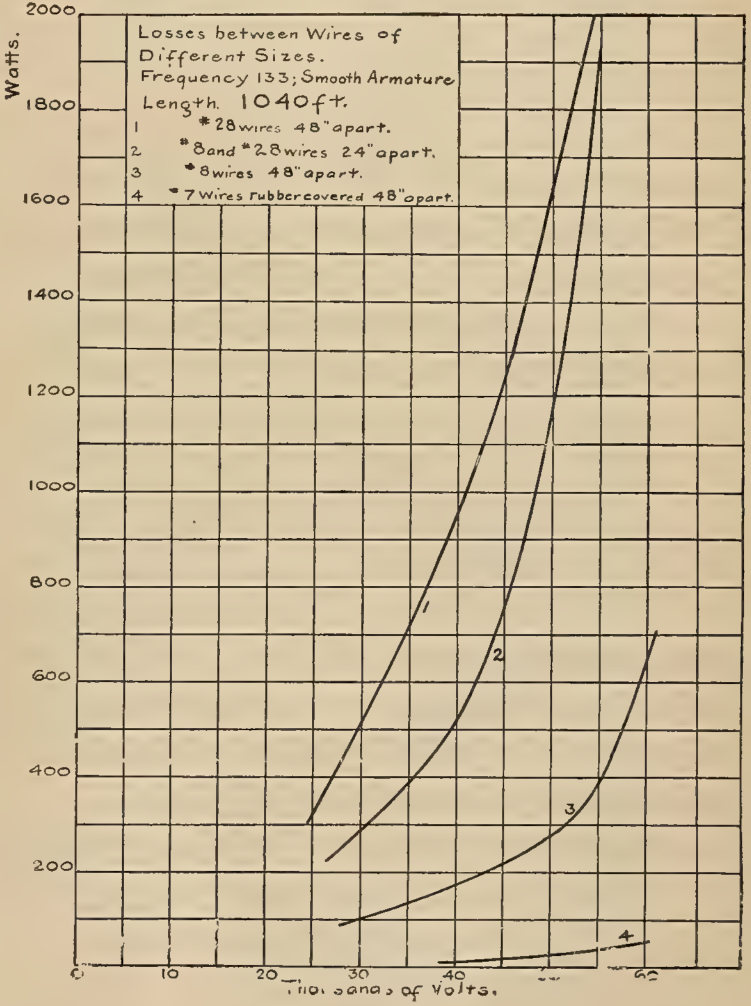


FIGURE 13.

(6) It was noticed that when there was a break-down upon the line and the current passed suddenly between wires over the surface of the cross-arm that there was a sparking between the terminals of the ammeters in the high-tension circuit across the surface of the instrument. This was further investigated by placing in circuit a coil of low resistance through which one ampere would be sent by about 1½ volts at a frequency of 125. A spark-gap was placed in shunt to this coil. A 2-inch spark-gap was placed between the line wires. The voltage of the primary was gradually raised until at 35,000

(Continued on page 126.)

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of
Electricity and Transmission of Power.

Official Organ of the Pacific Coast Electric Transmission Association.

Subscription invariably payable in advance. Terms—Domestic, One Dollar per Year; Foreign, Two Dollars per Year. The trade supplied by the San Francisco News Company. Advertising rates furnished on application.

GEO. P. LOW, : : : Editor and Proprietor

PUBLICATION OFFICE:
320 CALIFORNIA STREET,
ROOM 14.

Address all communications to
Editorial rooms, 427 TENTH AVE.
Telephone, "Steiner 627."

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME VI DECEMBER, 1898 NUMBER 6

EDITORIAL.

SCOTT ON HIGH-VOLTAGE TRANSMISSION.

Mr. Charles F. Scott's paper on "High Voltage Power Transmission," read before the Omaha meeting of the American Institute of Electrical Engineers, is of such potent value to the electrical transmission interests that it is reprinted, practically in full, in this issue. Being the effort of one of the highest authorities on electric power transmission, as well as one who has had enequalled opportunities for the experimentation and study of high potential phenomena under working conditions, the paper may be accepted as a most authentic statement of the present condition of electric transmission work, particularly with reference to the use of high electromotive forces. We of the West look upon Mr. Scott's paper with no little measure of gratification, for it not only discusses Pacific Coast plants more freely than similar enterprises located elsewhere, but it confirms, in all material points, the essential details of transmission work that have been accepted here as settled practices.

Interest centers, of course, in the remarkable series of high tension experiments which were carried on at Telluride in conjunction with Mr. L. L. Nunn of the Telluride Electric Power Company, wherein pressures running up to 110,000 volts were tried upon the experimental line, although the paper does not state the fact of the trial of the electromotive force just named. The inference from the paper is that individual transformers may be relied upon to deliver 60,000 volts with satisfaction even under varied service and considerable periods of inactivity. To quote the author: "The making of a single large transformer for a very high voltage naturally involved new difficulties. Above 10,000 or 20,000 volts there was an unexplored and uncertain field in the matter of insulation. Materials which were commonly used at ordinary voltages might have very different characteristics under the new conditions. . . . . The large high tension transformer of today was not designed in a week or a month, but it has been an evolution, based upon experimental tests and experience in continued operation."

The insulator is characterized as "the fundamental factor in transmission," and the glass type of insulator is preferred for reasons which have already been given in these columns. The underhung type of insulator, which many believe to possess advantages, proved to be unsuccessful and unsatisfactory. It was "heavy and cumbersome, and no satisfactory method was devised for holding the wire. A wooden pin lacks strength and a metal pin reduces insulation. Moreover, smaller insulators of the ordinary form were found suitable for higher pressures than was anticipated."

The most prominent, if not the only instance of the use of underhung insulators on the Pacific Coast is by the Montana Power Company, transmitting power from the Big Hole River to the city of Butte, Mont., a distance of 20.6 miles, and the underhung insulators there in use are reported to be satisfactory, particularly because the banking of snow under them is impossible. As to the pin question, practice will probably center in the use of well treated wooden pins, or, when unusual strains are to be provided for, special pins of steel that are sheathed and capped with treated wood will perhaps come into general use. With these high electromotive forces, the length of the pins must be materially increased, which will probably necessitate the redesigning of the pin and insulator to enable the pin to be of such dimensions as will resist the additional strains imposed by the increase in length. The observation that smaller insulators of the ordinary form are suitable for higher pressure than was anticipated, seems especially pertinent after looking over the Pomona line, where the entire petticoats of hundreds of the Pomona type insulators have been shot away; where those of these insulators that were shattered so as to be unfit for further service have been replaced with ordinary glass telegraph insulators, and where service runs on uninterruptedly over Pomona type, petticoatless glass "stumps," and telegraph insulators as though it were not carrying the pressure that was looked upon six years ago as enormous.

Rain, in falling on porcelain insulators, preserves the form of the drops and rolls off as though the insulator were oily; but with glass insulators the moisture spreads all over the surface on reaching it. That the condition of the insulator is materially improved during rain by the action of the current was shown at Telluride by applying 45,000 volts to a circuit, when the wattmeter indicated 116. After four minutes the deflection decreased to 72 watts, the current remaining the same. The electromotive force was then increased to 60,000 volts, the wattmeter deflection increased to 155, and at the end of three minutes it had fallen to 138. The current was one-third greater than at the lower voltage, but remained constant while the wattmeter changed. Data of value would be given were it stated what approximately the wattmeter reading would probably have been were the line dry, in order that some determination might be made regarding the amount of energy expended in the so-called "drying" of insulators, as well as the real efficacy of such drying.

Regarding atmospheric conditions, the paper disabuses the once prevalent idea that line losses increased materially with increased humidity or dampness, by stating that "if there was any variation in the loss on the lines for the observed range of weather conditions, it was so small as to be inappreciable. The results of all measurements taken seem to confirm the fact that the only weather conditions whatsoever which affect the loss to any practical extent is that of precipitation. The loss seems to bear some relation to the size of the particles precipitated, being greater for a fall of snow in which the flakes are large than one in which the flakes are small." The influences of fogs are not discussed and it is presumed that there is no fog at the Telluride plant. Fog is, however, of no consequence, as the experiences of the San Joaquin and Santa Cruz transmissions have demonstrated.

Of the feasibility of transmission at 40,000 volts even under most trying climatic and atmospheric conditions, there is no shadow of doubt, for its commercial practicability has been fully demonstrated in the Provo-Mercur installation which has been running now for a year or so through every possible variety of weather at the high electromotive force named. Transmission at 50,000 volts has not been tried on a commercial scale as yet, but the experiments thus far with lines at that pressure seem to indicate that the bulk of California transmissions would experience no more difficulty in operating at 50,000 volts than is found with the present potentials, provided of course, that insulators, pins and cross arms of the most approved types were used.

ELECTRIC POWER IN THE PRESSROOM.

The *Inland Printer*, which embodies all that is best in the art preservative, and is to typography and presswork what THE JOURNAL OF ELECTRICITY is to electric transmission interests, (becoming modesty, this!) gives an unqualified endorsement to electric power in the pressroom by stating in its Christmas edition that when we consider that a printing press for a daily newspaper is in use only a few hours out of each twenty-four, that its output may vary within very wide limits, and that under the old system steam was kept up and belting running for a considerable time before and after the edition was actually printed, it is seen that the starting or stopping of a press by the turning of a hand switch results in a much more economical output of power. Among the practical difficulties which always existed in the pressroom of a large daily newspaper run by belting, was the fact that two men were always required to put the press in motion, if only for oiling purposes. This was because one man had always to stand by the belt to slip it on the pulley, while the other climbed up to oil bearings or to the semi-cylindrical stereotype plates on the printing cylinder. As the belt had only one invariable speed, and it took perceptible time for the man at the press to call out to the man at the belt, and for the man at the belt to throw it on to the idle pulley, the press was frequently turned past the desired mark, and had to be put through another revolution to again reach it. The electric motor, with twenty different rates of speed, between "dead slow" and full speed, and with "stop" buttons placed within easy reach of a man's hand in every part of the machine, has changed all this, so that what is now comfortable for one man to do, was formerly a thankless job for two men to attempt together.

Passing Comment

An Editorial Review of Current Events and Contemporary Publications.

TESLA'S LINELESS POWER TRANSMISSION SYSTEM.

Nikola Tesla, to whose lines of research and invention the electrical world owes much, has secured patents on a novel system "of electric power transmission through natural media," and which, briefly described, consists in the generation of extremely high electromotive forces, even up into millions of volts, and the transmission of electrical energy from point to point thereby through the rarified atmosphere of the high altitudes. A description of the proposed system will be found in the *Electrical Review*, (N. Y.) for October 26th, together with a full page view of a Tesla oscillator, photographed in action, showing that the actual width of space traversed by the luminous streams issuing from a single terminal is over sixteen feet; that the area covered by the streamers is approximately two hundred square feet, and that the estimated effective electric pressure is two and one-half million volts. From the description, which is taken from the patent specifications, it appears that the generating and receiving stations do not differ from present practices in power transmission plants of today, but the novel features consist in the spirally wound coils of the raising and lowering transformers, and the conduction of the high potentials named to rarified strata of atmosphere as by balloons, a grounded return being used.

The times are not ripe for the acceptance of the views implied by the inventor. More than that, other ideas suggested and patented by him bear to a marked extent the imprint of day dreaming and unhealthful pandering "to the gallery" through the lurid columns of Sunday papers, and his once great name has suffered a possibly irreparable injury. Still, as stated, the engineering world owes much to his fertile brain, and its seeming degeneration can only excite pity and regret.

* * *

THE LIMITATIONS OF POWER TRANSMISSION.

The first duty of ever company distributing electric power for whatever purpose intended, is to provide for an uninterrupted service, says *The Electrical Engineer*, (N. Y.) for without this no customer will be satisfied, and without satisfied customers there can be no progress from a financial standpoint. It does not by any means follow that every water power can be successfully transmitted to long distances. The conditions which determine success, however, can in every case be fairly well prognosticated, but such prognostication ought to be left in the hands of most competent engineers. Nor does it follow that a water power transmission is subject to any other general laws as to loading, than is a steam plant. In fact, the advantage, if any, is on the side of the latter, for whereas a steam plant can, in case of emergency, be forced considerably beyond its normal capacity for extended periods of time, such is not the case with a water power plant. It follows, therefore, that to load up a water power plant beyond its capacity is a practice that will sooner or later bring on trouble. All these troubles can, however, be avoided by judicious management, and examples that have been cited seem to indicate that had due precautions been taken, unfavorable results could have been avoided. Certain it is that the art of electric power transmission is now so well established and its limitations are so well understood, that there can be no excuse for failure.

Gas

ACETYLENE.*

BY PROF. VIVIAN B. LEWES, F. I. C., F. C. S.

I.

ACETYLENE, on analysis, is found to contain 92.3 parts of carbon and 7.7 parts of hydrogen. It has a density of 0.92. When prepared by the action of water upon calcic carbide it has a very strong and penetrating odor, but when the gas is thoroughly purified from sulphuretted and phosphoretted hydrogen, which are invariably present in it in minute traces, this pungent odor disappears and the pure acetylene has a not unpleasant etherial smell. It is readily soluble in water which, at normal temperature and pressure, takes up a little more than its own volume of the gas, and yields a solution giving a purple-red precipitate with ammoniacal cuprous chloride, and a white precipitate with silver nitrate, these precipitates consisting of acetylides of the metals.

SOLUBILITY.

The sulubility of the gas in various liquids, as given by different observers is as follows: 100 volumes of brine absorb 5 volumes of acetylene; 100 volumes of water absorb 110 volumes of acetylene; of alcohol, 600 volumes; of paraffine, 150; of carbon disulphide, 100; of fusil oil, 100; of benzine, 400; of chloroform, 400; of acetic acid, 600; and of acetone, 3100 volumes. It will be seen from this that where it is desired to collect and keep acetylene over a liquid, brine is best for the purpose; but in practice it is found that unless water is agitated with acetylene or the gas is bubbled through the water, the top layer soon gets saturated and the gas then dissolves but slowly.

EXPLOSIONS.

When acetylene was first introduced on a commercial scale, grave fears were entertained as to its safety, it being represented that it had the power of combining with certain metals, more especially copper and silver, to form acetylides of a highly explosive character, and that even with coal gas, which contains less than one per cent. of acetylene, such copper compounds had been known to be formed in cases where the distributing mains were of copper, and that accidents had happened from this cause. It was, therefore, predicted that the introduction of acetylene on a large scale would be followed by numerous accidents, unless copper and its alloys were rigidly excluded from contact with the gas. These fears, however, have fortunately proved to be absolutely unfounded; and the original gas fittings can be used with perfect safety with acetylene. This point was exhaustively experimented upon by H. Gerdes, the chief engineer of Messrs. Pintsch, of Berlin, in the summer of 1895, in which the gas was not only used under ordinary pressure, but also mixed with oil and coal gas at pressures of nearly ten atmospheres. Of all the metals and alloys used, the ones which are known to resist ordinary oxidation in the air remained perfectly unaffected, while the easily oxidizable metals suffered on the surface; but in no instance was it possible to trace any acetylene compound, and no explosion could be produced either by heating or hammering. If, however, acetylene be passed through an ammoniacal solution of cuprous chloride, copper acetylid is formed, and when dry this explodes with great violence when struck or when heated. Independent observations made by M. Bullier showed that in order to obtain this explosive compound of acetylene and copper, it was necessary that the gas should come in contact with a sub-salt of the metal in the presence of an excess of ammonia, and as in actual practice these conditions would never be realized, it is manifest that the alleged danger may be disregarded. As to the charge that it is a highly poisonous gas, the very extensive experiments of Dr. Grehant, Brociner, Malooz, Crismer and others, all conclusively show that acetylene is less toxic than carbon monoxide, and, indeed, less than coal gas.

LIQUIFICATION.

Acetylene can be condensed into a liquid by cold or by pressure. Experiments by Ansell show that if it be subjected to a pressure of 21.53 atmospheres at 0° C., it is converted into a liquid state, the pressure required increasing, of course, with the rise of the temperature and decreasing with the lowering of the temperature, until, at 82° C., it becomes liquid under ordinary atmospheric temperature. With the advent of calcic carbide, acetylene assumed a position of commercial importance and a great future was expected from its use in liquid form, as a cylinder fitted with the necessary reducing valves would supply the gas to light a house for a considerable time, the liquid occupying between 1-400th and 1-500th of the volume of the gas. But where liquid acetylene has been made on a large scale, several fatal accidents have occurred owing to its explosion under not easily explained conditions. Berthelot and Violle have found that if liquid acetylene in a steel bottle be heated at one point by a platinum wire raised to a red heat, the whole mass decomposes and gives rise to tremendous pressures varying from 71,000 to 100,000 pounds per square inch. The liquid could not be detonated by shock. This decomposition did not spread far beyond the point at which it was started if the liquid was at ordinary pressure, but if it was under a pressure of more than thirty pounds per square inch, the decomposition became a detonation throughout the mass. These results showed clearly that liquified acetylene is far too dangerous for general introduction for domestic purposes, and in England its storage and use is prohibited.

COMBUSTION.

If acetylene in contact with air be heated to 480° C., it ignites and burns with a flame the appearance of which varies with the way in which the gas is brought in contact with the air. With the gas in excess, a heavy, lurid flame, emitting dense volumes of smoke, results, while if the gas be driven out in a sufficiently thin sheet, it burns with intense brilliancy and almost perfect whiteness by the light of which colors can be judged as well as by daylight. Acetylene can be ignited with any red hot carbonaceous matter, such as the glowing end of a cigar. For its complete combustion, acetylene requires 12½ volumes of air, and forms, as its products of combustion, carbon dioxide and water vapor. If, however, the air is in much smaller ratio, incomplete combustion ensues and carbon, carbon monoxide, carbon dioxide, hydrogen, and water vapor are produced. It is probable that when a flame is smoking badly, distinct traces of carbon monoxide are being produced; but when it is burning properly, its products are as harmless as are those of coal gas, and, light for light, very much less in amount. For all practical purposes the explosive limit of acetylene with air may be taken at 3½ per cent. of acetylene, and an explosive mixture of the gas and air attains its maximum power with a mixture of 12½ volumes of air to one of acetylene. Ordinary coal gas forms an explosive mixture between the limits of 6 and 29 per cent., and yields its maximum result with a mixture of one volume of coal gas to about ten volumes of air.

(*To be continued.*)

---

[*] Abstract of a series of four Cantor lectures delivered to the Society of Arts, London.

Physics

ENERGY RECEIVED FROM THE SUN.

BY PROF. L. G. CARPENTER.

IT is well known that the sunshine on our Western plains is much greater in amount than that received by the East. For ten years the author has maintained observations on the intensity of the energy received from the sun, (using the Arago-Davy conjugate thermometers) and also observations on the amount of sunshine. The observations show an intensity of from 7 to 17 calories per square meter from 8 a. m. to 5 p. m. on sunny days, or from ½ to 1.4 horse-power per square yard. It seems as reliable as the wind, which is extensively used as a source of power for small plants.

Hydraulics

HYDRAULIC EQUIVALENTS.

According to G. Olivio Newman, C. E., one miners inch of water under four inches pressure above the center of the opening flows in one second 0.02 cubic feet, or 0.1496 gallons; in one minute, 1.2 cubic feet, or 8.976 gallons; in one hour, 72.0 cubic feet, or 538.56 gallons; in twenty-four hours, 1728.0 cubic feet, or 12925.44 gallons.

One cubic foot per second equals fifty inches under four inches pressure.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

SOMETHING NEW IN MOTORS.

There is nothing holds the fancy of the practical mechanic like a well constructed piece of machinery. In this age of change and rapid improvements electric motors have, of necessity, kept pace with the times.

The latest improvements have been embodied in a large shipment of Sprague-Lundell motors which has lately reached the Brooks-Follis Electric Corporation. Their large storerooms at 523-525 Mission street, now contain the most complete stock of motors, ranging from $\frac{1}{12}$ to 25 horse-power, on the coast.

For beauty of design, superiority of construction, and perfection of detail, the Sprague-Lundell motors are unrivaled. This is not an idle boast. The Brooks-Follis corporation has issued a cordial invitation to its competitors and customers to inspect the latest thing in the way of motors, and the generous praises which the Sprague-Lundell's have called forth, is the highest tribute possible to bestow.

The manufacturers of these motors use the highest grade Sterling Extra Insulating Varnish in the construction of their apparatus. This varnish, so well known to the electrical trade, is manufactured by the James Todd process and patents. Its many good qualities have induced the Brooks-Follis Electric Corporation to accept the agency for the Pacific Coast, and, on its merits, they are vigorously pushing the sale of this varnish with gratifying success.

THE CENTRAL ELECTRIC CO. IN SAN FRANCISCO.

The Central Electric Company of Chicago, through its Pacific Coast agent, Mr. A. I. Neisser, of Los Angeles, has established an office at 530 California street, San Francisco, with Mr. Otto Neisser in charge. All communications addressed there or to the Los Angeles office, 327 Fred J. Byrne building, will at all times receive prompt attention.

The General Electric Company has established a sales office in the Templeton Building, Salt Lake City, Utah. It is in charge of Mr. B. E. Chubbuck.

Trade Literature.

(Catalogues mentioned in this department will be mailed gratuitously on application to the concerns publishing them. When writing, mention THE JOURNAL OF ELECTRICITY. Where addresses are not given, they may be found through refereuce to the Advertisers' Index on page iii.)

"Enclosed Arc Lamps, (No. 1015). An artistic brochure of 58 pages discussing the many advantages of enclosed arc lamps and describing the special forms of those manufactured by the publisher of the booklet. From the press of the *General Electric Company*.

"Knight's Water Wheels." A catalogue of the well known Knight water wheels, rock breakers, hydraulic engines, traction engines, centrifugal pumps, mining dredges, etc., the greater portion of which is devoted to water wheels. Some very valuable hydraulic tables are included. *Knight & Company*, Sutter Creek, California.

"Electricity in Paper Making." A 30-page reprint of a paper read by Chas. F. Scott, chief electrician of the Westinghouse company, before the American Pulp and Paper Association. Although the introductory deals largely with electrical equipments as applied to paper making, the latter portion of the pamphlet contains an exceedingly clear exposition of the general principles underlying the action of electrical equipments of almost every description. *Westinghouse Electric and Manufacturing Company*.

"Generators and Rotary Transformers for Electrolytic Work," and "Polyphase Inductor Generators," (Catalogues Nos. 200 and 201 respectively). Monthly bulletins of twelve and twenty pages, freely illustrated and of standard size for binding. No. 200 describes and discusses the characteristics of electrolytic apparatus of various capacities up 850 kilowatts, while, similarly, No. 201 describes the salient features of the polyphase induction generators recently brought out by the Westinghouse company. An excellent feature of most of these circulars is the dimensional data given by means of outline drawings and tables. *Westinghouse Electric and Manufacturing Company*.

"Industrial Railways," (No. 9805); "Mast Fittings, Coal Tubs, Hoisting Blocks and Wheelbarrows," (No. 9807); and "Manila Rope," (No. 9811). Three freely illustrated and valuable catalogues of 48, 20 and 42 pages respectively, pertaining to the subjects named. Each describes special appliances of the highest states of their arts. No. 9805, for instance, is a treatise on sectional track, road beds, curvatures, etc., while the brochure on Manila rope is perhaps the most interesting dissertation on Manila fibre and the making and uses of rope that has ever been published. It describes various methods of splicing and shows how to tie about thirty of the knots, hitches or bends that are most frequently used, but the most valuable portion is that devoted to rope driving, which consumes about twenty pages of tables, rope transmission curves, diagrams and descriptive matter. *The C. W. Hunt Company*. 45 Broadway, New York.

SOME LETTERS TO THE EDITOR.

"Your San Gabriel edition is worth the price of a year's subscription."—STEPHEN D. FIELD, Stockbridge, Mass.

"For thorough and able treatment, the descriptions contained in the articles from your own pen on 'Electric Storage in an Edison Station,' and 'The San Gabriel-Los Angeles Transmission,' rank among the best of their class to be found in modern electrical journals."—FRED'K RECKENZAUN, electrical engineer, New York.

"I have just received a letter from Omar DeBast, professor of Electro-technology at Montefiore Institute of Electricity, in Liege, Belgium, which I consider to be the best school of electricity in the world. In this letter Prof. DeBast says: 'While in Europe you had the kindness to send me a few numbers of THE JOURNAL OF ELECTRICITY of San Francisco. Permit me to thank you for the favor. I found the JOURNAL exceedingly interesting.' Mr. Editor, will you kindly forward a year's subscription to Prof. BeBast, sending the bill for the same to me?"—A. VAN DER NAILLEN.

HIGH-VOLTAGE POWER TRANSMISSION.

(Continued from page 121.)

volts the current passed across the spark-gap betwen the line wires. A spark also crossed a gap of ⅜-inch, shunting the small choke-coil. This test shows the remarkable suddenness of the rush of current when the short-circuit occurs due to the breaking down of the spark-gap on a high-voltage circuit. This phenomenon was observed by Mr. Mershon in choke-coils used in connection with lightning arresters at Telluride.

Running tests were made on four lines in multiple at high voltages. Each line consisted of two wires 1,040 feet in length held by 26 insulators. The insulators were of the various types of glass and porcelain, some of the ordinary form and some underhung. For hours at a time, 100,000 volts or slightly more were kept upon the line. For about six weeks, voltages ranging from 70,000 or 80,000 to 100,000 volts were kept on the lines for about eight hours a day. When there was rain the line would short circuit, and the voltage had to be reduced. During a driving rain-storm, 48,000 volts was kept on the lines, and it may have required a considerably higher voltage to have caused short-circuiting.

(7) A high-tension wattmeter similar to the Thomson wattmeter at Telluride was used. To correct the wattmeter for the errors caused by charging current in the shunt resistance, a condenser was placed in parallel to the shunt circuit of the wattmeter. This condenser should be so adjusted that the current through the shunt circuit of the wattmeter is the same that it would be if there were no condenser and the shunt resistance had no capacity. This permits the capacity current in the circuit to be shunted around the wattmeter by the condenser. The condenser in shunt to the wattmeter was capable of adjustment, and by varying its capacity the deflection could be made positive or zero or negative when current was delivered to a constant load. The proper adjustment was made by taking a comparatively low voltage, at which the charging current was very high in comparison with the loss, so that the loss was nearly negligible, and adjusting the wattmeter to indicate zero. At higher voltages, when there was a considerable loss, the error with this adjustment would be inappreciable. Certain variations with temperature and humidity were noted which would be explained by a variation in the capacity of the resistance, causing a variation in the charging current to the shunt circuit of the wattmeter. The high resistance for the shunt circuit was wound upon fuller-board plates containing brass stiffening pieces. Tests were made upon individual plates by measuring the capacity between the wire and the supporting strip of brass, and it was found that the capacity and the insulation resistance both varied with the amount of moisture in the fuller-board insulation. In order to prevent variations of this kind, subsequent resistances were wound upon glass plates, which seems to be a very satisfactory form of construction.

TESTS AT NIAGARA.

Some measurements have been made upon the Niagara-Buffalo transmission line. There are two circuits of three wires each, one of which was in service and the other was available for tests. Each circuit consists of three cables each of 350,000 c. m., about 0.7 inches in diameter. The cables are run on porcelain insulators, and are on the same cross-arm. Adjacent insulators are 18 inches apart and the circuit is spiralled, so that each of the three wires occupies the middle position for a third of the distance. Current from one of the 5,000 h. p. generators was applied to the line through a raising transformer, by which the voltage can be increased by small steps to 100,000 volts. This transformer is part of a high-tension testing outfit which is described by Mr. C. E. Skinner in the *Electrical World*, March 5, 1898. The wattmeter is a Thomson inclined coil instrument with a high resistance shunt of german silver wire wound on glass plates. The ammeter is a Thomson inclined coil instrument, connected directly in the high-voltage circuit.

Measurements were made between the various pairs of wires, i. e., 1 and 2, 2 and 3, and 1 and 3; the current was found to be practically the same in each case; the loss on one of the circuits was slightly greater than that on either of the other two, on which the losses were about equal. The accompanying curve shows the measurements of current when two wires were connected, and the measurement of loss; the latter measurements were made upon one pair of wires up to about 26,000 volts, and then upon a second pair. The results are given in Fig. 14.

On another day, measurements were made of the resistance between each wire and the ground, and corresponding measurements of loss were made by placing the high potentials between each wire and the ground. The measured loss was somewhat greater than the loss calculated by using the E. M. F. and the measured resistance. In these measurements, at voltages from 13,000 to 23,000 volts, the power factor calculated from the current and wattmeter measurement, varied from about 4 per cent. to 6 per cent., so that a very small charging current in the wattmeter would produce a considerable error in the reading.

Some measurements were made upon a pair of fine wires, in which the wires were placed at different distances apart. No. 31 B & S gauge spring brass wire 8.9 mils in diameter was used. The length of the parallel wires was 744 feet. They were suspended by light strings successively at 6 inches apart, 14 inches apart, and 25 inches apart, the distance varying from 24 to 27 inches. The wattmeter readings are given in the curves in Fig. 15. The power factor of the measuremtns made above 100,000 volts is about 95 per cent ,.and is over 80 per cent. above 70,000 volts. There can be but little error in the wattmeter due to charging current in the resistance at these power factors.

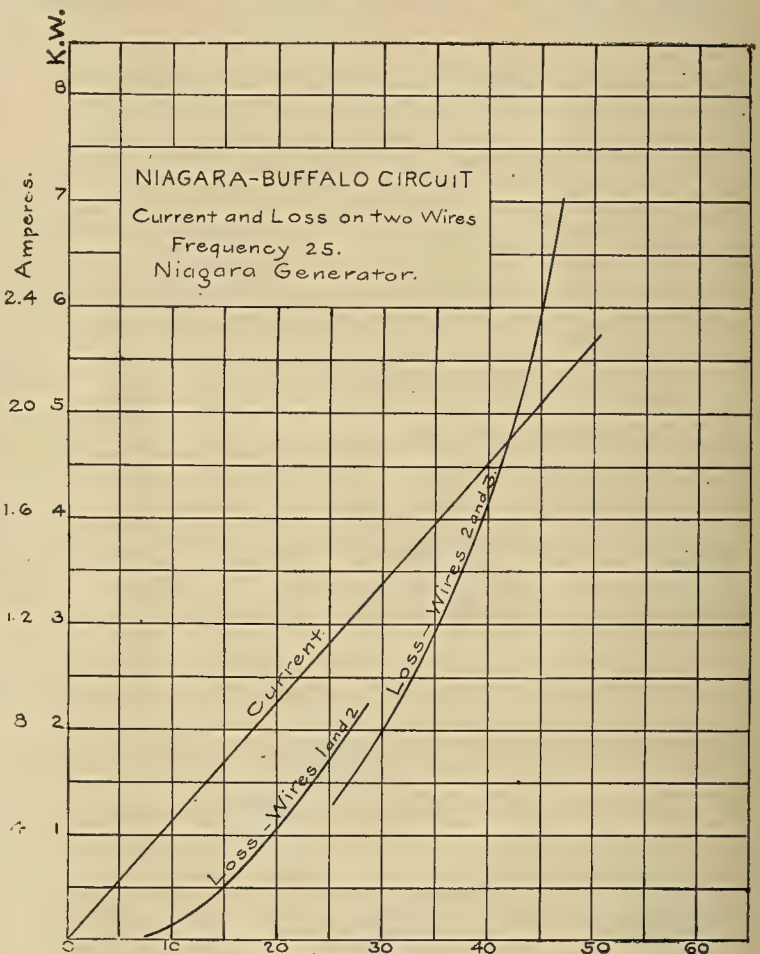


FIGURE 14.

TRANSMISSION PLANTS IN OPERATION.

Beginning with the plant at San Bernardino and Pomona, which began operation in 1892, using 10,000 volts and transmitting 30 miles, a constantly increasing number of plants have been installed operating at 10,000 or 15,000 volts. In some cases there has been little or no trouble experienced with the transmission lines, while in other cases the experiencs have been less satisfactory. The principal trouble seems to have been a poor grade or an insufficient size of porcelain insulator. In other cases, the insulators, sometimes porcelain and sometimes glass, have given almost perfect satisfaction.

The superintendent of a power company which has been running fifteen months with about 15,000 volts, reports that they "have had absolutely no trouble whatever of an electrical nature." Some insulators were broken because they had been used as targets by small boys or hunters, but only the outer petticoats were broken, and no short-circuits occurred, although in some cases insulators were in use for months with most of the outer petticoats chipped off. The distance of transmission is twelve miles. Porcelain insulators are used.

In another plant, which has been in operation about a year and a half, employing 15,000 volts for a distance of nearly thirty miles, there have been but three shut-downs on account of line difficulties. These were due to the breaking of insulators at a point where the line was spiraled. In one case, the repair was made in half an hour, and the other case a few minutes interruption to service was sufficient for repairs.

The line is regularly patroled, and if a defective insulator or pin is found, the generating station is notified by telephone, and the line is shut down for a few moments at noon. In one case two poles were burned by a defect in the insulators on the top of each. The poles burned to the ground, leaving the line hanging clear without any one at either the generating station or sub-station being aware of the fact

Troubles have arisen on some lines by the burning off of pins by the passage of sparks from the outer edge of the insulator to the pin. These sparks make small holes in the pin, no larger than a needle-point, but after continuous sparking for some time the pin becomes entirely charred. An iron pin suggests itself as a remedy, but additional strains and liability to breakdown are liable when a conductor is placed within the insulator. The burning off of pins has occurred where small porcelain insulators are porous and the outside glaze is imperfect, while the glaze on the inside is good. When the porcelain is filled with water, the current readily passes through it to the lower rim of the insulator, and then sparks across to the pin. In one place which has been running for about three years some 250 pins burned off. The early insulators have been replaced by larger and better ones, and this defect has disappeared.

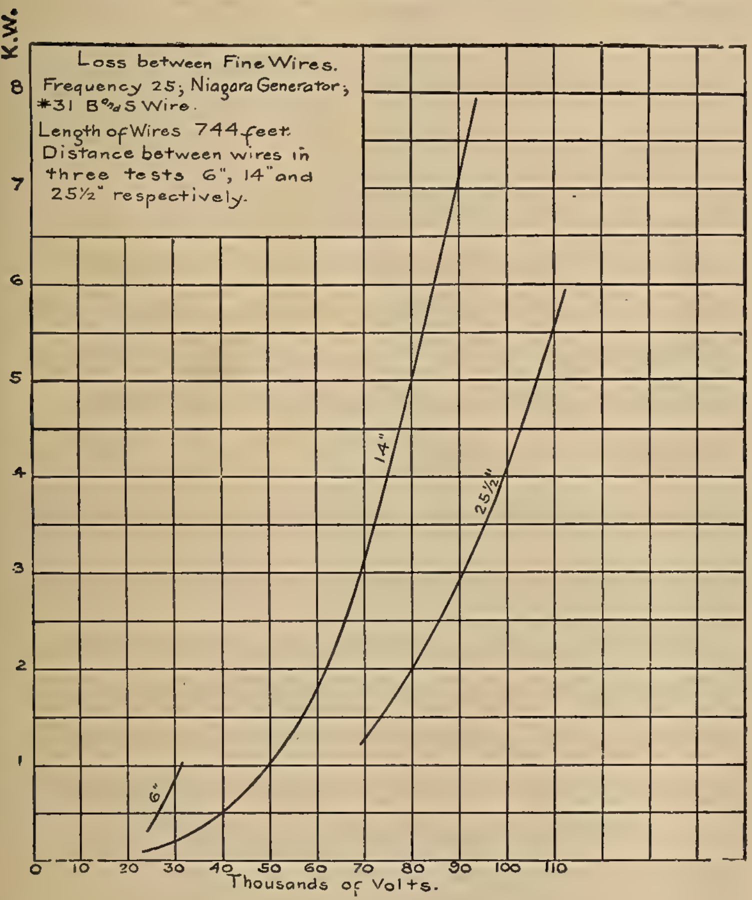


FIGURE 15.

A 10,000 volt-line, which runs for a dozen miles or more within a few hundred miles of the Pacific Coast, has burned cross-arms on nearly every pole. The cross-arms near the ends of the line, which are away from the coast, are not burned. Usually, the burning appears as a mere blackening of the cross-arm for a short space between the insulators, on one side of the arm. In some cases, the charring is deeper, and appears on both sides. The side on which almost all of the burning occurs is the one toward which the winds come from the ocean, bearing the mist of salt water. The wire shows discoloration, and the iron braces for holding the cross-arms are, in a few cases, eaten through. Moreover, the cross-arms were green and full of sap when erected. The early porcelain insulators were porous, and have now been replaced, and the pins are of iron. The charring has ceased almost entirely since the new porcelains were put up.

It may be observed that in the plants which are herein referred to, and in the experimental tests, no mention has been made of insulators with cups containing oil for reducing the surface leakage. Insulators of this kind were used in the Frankfort-Lauffen experimental transmission line at 30,000 volts. Practically, however, the surface insulation is adequate without oil cups, and the principal duty of the insulator is to prevent the current passing over the surface and jumping to the pin or cross-arm, a matter with which the oil would have nothing to do.

Telephone lines are in use in a number of plants placed on the poles which carry the transmission wires. The telephone lines are usually placed some distance below the transmission wires, and are crossed at frequent intervals. The telephones in general work very satisfactorily.

There apepars to be practically nothing in power transmission in Europe using high potentials, outside of Switzerland. The installation in Paderno, in Switzerland, is operating at 15,000 volts, the highest voltage which has been used in that country. The damp weather is one of the limiting factors. The insulations used are porcelain with a triple petticoat.

40,000 VOLTS IN COMMERCIAL SERVICE.

The highest voltage which is used for transmission is in the Provo plant of the Telluride Power Transmission Company in Utah, which transmits power 35 miles to the Mercur mills at 40,000 volts. Raising transformers are three in number, and are connected in the star form. Each transformer has a capacity of 250 k. w. The middle points of both the high-tension and low-tension circuits are grounded. In general design, these transformers resemble the transformers used in the high-tension tests at Telluride; the design and construction having been under the direction of the same man in both cases. The line extends from Provo at an elevation of 4,500 feet to Mercur, at 2,000 feet above Provo, and the line reaches an extreme height of about 10,000 feet above the sea level. Three miles of the line are strictly mountain construction. The lightning protection is afforded by choke-coils and Wurts non-arcing metal arresters. The insulators are of glass. The design was based on the tests at Telluride, and they were made especially for this plant. The form is shown in Fig. 16. The insulators are held on special pins of oak which are thoroughly paraffined. The lower part of the insulator is 5" above the cross-arm.

In dry weather, there has been no difficulty whatever in operating. The insulators do their work as effectively as could be expected if the voltage were only a few thousand volts. When everything is dry, the line will operate without difficulty, even if some of the insulators are off and the wire rests upon the cross-arm. When it rains, there is sometimes trouble. It is indicated in the station by the ammeters giving quick swings, showing momentarily strong currents. Sometimes this is apparently a short-circuit and blows a fuse. In every case when there has been trouble on the line it has been in rainy weather, and broken insulators have been found which located the trouble. It is certain that in most cases these have been previously broken by bullets, and in other cases it is probable that the insulators were likewise broken. It is believed, therefore, that had there been no intentional breakage of insulators there would have been no trouble upon the line since the plant began operating in February last. A few of the insulators near the station are not far from the overflow, and are in a moisture equivalent to a rain all the time, without doing any damage. Snow has often backed from the cross-arm up against the bottom of the insulator and around the first petticoat. It is usually found that the part of the insulator around and near the wire does not receive deposits of moisture or frost but remains dry, the particles being repelled. At this plant, current for about 700 h. p. is carried through three fuses of copper wire 10 mils in diameter. Iron wire is used on a branch line for transmitting about 100 h. p. for about three miles.

This plant has been in operation in winter and in summer, "in thunder, lightning, or in rain," the sole supply of power for the enormous De Lamar mines and mills at Mercur, and is a happy and fitting consummation of the high-tension tests described in the beginning of this paper.

LIMITATIONS OF HIGH-VOLTAGE TRANSMISSION.

The important commercial question is: To what distance can power be transmitted? The relation between distance and voltage is well known. The same weight of copper can transmit with equal efficiciency the same power to any distance, provided the voltage is increased directly as the distance is increased. The limiting commercial ratio between voltage and distance is easily found. If the distance be three miles per thousand volts, and the loss 16 per cent., the cost of copper is about $20 per h. p. The interest on the latter investment is about $1 per year. A distance in miles equal to three times the number of thousand volts may therefore be covered without an excessive annual charge per h. p. for copper. The limits to the voltage which are practicable depend principally upon the insulator and upon the loss between wires.

The Insulator—The two fundamental requirements are dielectric strength sufficient to prevent puncture, and a size and form which will prevent the passage of the current around the insulator. A given insulator will be adequate for a higher voltage where the atmosphere is comparatively pure and dry, than it will be under other conditions. The rapid progress which has been made in the design and construction of insulators during the last few years will doubtless provide an insulator which will accommodate the highest voltages that can be used due to other limitations. The insulator, therefore, while remaining the critical point in a transmission system will probably not determine the limit of practicable voltages.

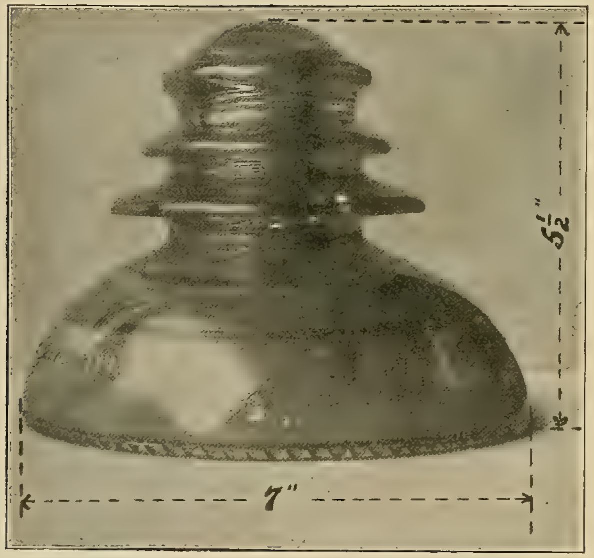


FIGURE 16.—INSULATOR USED AT PROVO FOR 40,000 VOLTS.

Loss Between Wires—The loss between bare wires at high voltages sems to determine a positive limit, beyond which the voltage cannot be increased. This loss is subject to variation due to diameter of wire, distance between wires, and wave form of the e. m. f., but the variations which may occur under favorable commercial conditions locate the point of increase of loss about 50,000 or 60,000 volts. Under favorable conditions this may be raised somewhat, but it is not probable that any material increase can be made.

Amount of Power—The amount of power to be transmitted involves some interesting commercial limits. There are certain elements in a transmission which do not vary greatly with the amount of power transmitted. Thus, the charging current to the line will be practically the same whether the wire will transmit 1,000 or 100 h. p. If the charging current happens to represent 300 h. p., it would be insignificant in one case, but for the smaller output it would require generating apparatus several times that necessary for the actual power.

It is not mechanically practicable to use wires as small as would be sufficient, in so far as conductivity is concerned, for transmitting a small power. For example, a No. 7 copper wire, which is as small as is ordinarily used, if employed in a 3-phase circuit fifty miles in length, would transmit over 1,000 k. w. at 40,000 volts with 10 per cent. loss. If only a few hundred kilowatts were to be transmitted, the cost per k. w. would be excessively high, and on the other hand a lower voltage could be used without undue loss. In some cases, indeed, where a high voltage is used for small power, as for example on a branch circuit, an iron telegraph wire would have ample conductivity. In other cases, an aluminum wire could be used to advantage, as an aluminum wire of the same conductivity as a copper wire has only about half the weight, and possesses greater mechanical strength in comparison to its weight.

It may also be noted that high-voltage transformers cannot be economically built for small output, as the insulation spaces required are so large. The cross-section of the copper is often not more than 10 or 20 per cent. of the area of the opening in the iron. The cost per k. w. increases very rapidly when the size of transformer falls under a few hundred k. w.

Cables and Conduits.—The overhead transmission line has been considered, and its limitations are the insulating strength of the insulator and the losses through the intervening medium. In a cable or a conduit the insulation must be provided continuously, instead of at points a hundred feet apart. Rubber-covered cables are made for 10,000 and 20,000 volts, but it is quite possible that it will not be commercially practicable to make cables for much higher voltages. The effect of continued electric stresses on the insulation of the cable, which is an unknown factor may prove to be a very important one. A conduit composed of a pipe containing oil, in which the wires are separated by glass tubes has been proposed. Many mechanical difficulties arise in constructions of this kind; the cost is high, and the action of continued high voltages on solids and liquids opens a field which is little known. A suitable insulation on the wires on high-voltage lines may enable higher voltages to be used than can be used with a bare wire.

Liquid air, with its high insulating properties, and the low temperature and consequent high conductivity which it would give to a conducting wire, may enable us to use air insulation in a new way.

Difficulties and Precautions.—High voltages have been referred to in this paper with perhaps undue familiarity. Familiarity with high voltages is not one which breeds contempt. A voltage which can produce sparks several inches in length, which can be felt through several feet of air, which causes hissing sounds, which produces luminosity, and which in a confined room generates strong odors of ozone, is one which creates profound respect. Dangers and difficulties accompany it, and the highest intelligence, vigilance and excellence must be employed to avoid accident and ensure success. While ordinary types of construction do not seem to reach their limitations until some 50,000 volts is reached, and pressures of this order have been and are in regular use, nevertheless they are not to be used indiscriminately or where they can be avoided. There are difficulties enough in handling 15,000 and 20,000 volts. As the pressure is raised, the liabilities to trouble increase at an alarming rate. It is, however, a fact that these voltages have been and can be used, and also that no new or modified methods of transmission will be required before 50,000 or 60,000 volts can be employed for distances up to 150 or 200 miles.

TABLE OF CONTENTS.

Illustrated articles are designated by an asterisk (*); Editorials by a dagger (†); Passing Comment by a double dagger (‡), and Industrial by a section mark (§).

† Electric Power in the Pressroom...... 123

Electro-Economics

§ Something New in Motors.............................. 125

Gas

Acetylene, by Prof. Vivian B. Lewes, F. I. C., F. C. S................. 124

Hydraulics

Hydraulic Equivalents............ 125

Physics

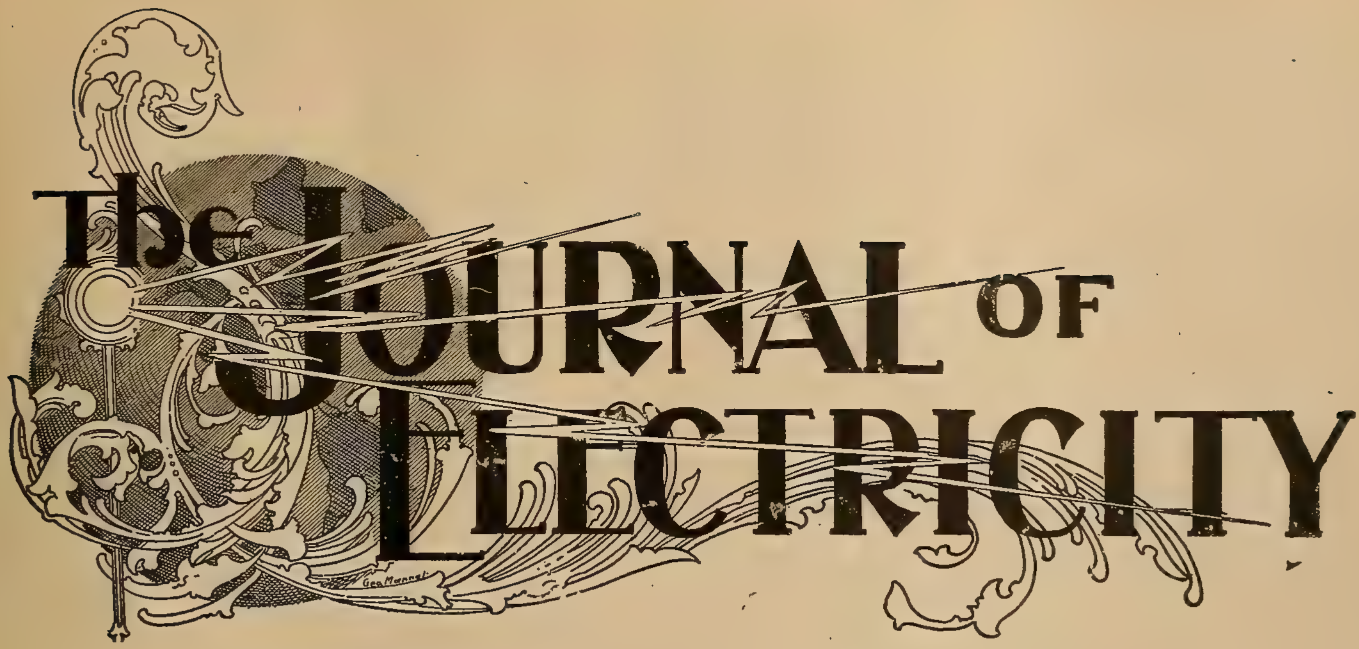
Energy Received from the Sun, by Prof. L. G. Carpenter........... 125

Transmission

* High-Voltage Power Transmission, by Chas. F. Scott.............. 113
† Scott on High-Voltage Transmission.................................. 122
‡ Tesla's Lineless Power Transmission System....................... 123
‡ The Limitations of Power Transmission..................... 123

Trade Literature

.... 125



The Journal of Electricity

VOLUME VII

JANUARY-JUNE

1899

SAN FRANCISCO, CAL.

Conducted by

GEO. P. LOW

INDEX TO VOLUME VII.

Illustrated articles are designated by an asterisk (*); Editorials by a dagger (†); Passing Comment by a double dagger (‡), and Industrial by a section mark (§).

PAGE

Authors

Arnold, Bion J. 39
Baldwin, Prof. C. G. 1, 23
Bates, Frank H. 53, 83, 92
Bean, Harry J. 37
Bell, Dr. Louis 15
Blondel, A. 100
Bowie, Jr., A. J. 21
Dickersen, Walter H. 81
Doolittle, C. E. 19
Forbes, Prof. George 97
Hunt, A. M. 24
Lambert, Carlton 50
Larkin, Geo. H. 24
Lewes, Prof. Vivian B. 10, 32, 47
Low, Geo. P. 69, 85
Lubcke, Chas. H. F. 33
Manson, Marsden 9
Scott, Chas. F. 18, 77
Stallard, J. H. 65
Swinburne, James 27

Electro-Therapeutics

§Endoscopic Lights 68
Incandescent and Arc Lamps in Therapeuty 84
The Old and the New in Theory 59

Electro-Economics

*Relative Costs of Conducting Systems, by Charles F. Scott 18

Financial

†"Fools Rush In Where Angels Fear to Tread." 60
†The Wrath of the People 96

Fraternal

Electric Transmission Association Meeting 84

Gas

Acetylene, by Prof. Vivian B. Lewes, F. I. C., F. C. S. 10, 32, 47
‡A "Joker" in Welsbach Lighting 80
Cheaper Gas for Power Purposes in Boston 50
Diesel Motors and Otto Gas Engines 34
Efficiency of Illuminants 67
Even Acetylene is Very Inefficient 67
Gas Engines in English Electrical Stations 81
*Industrial Gas, by Frank H. Bates 53, 83, 92
§Otto Gas and Gasoline Engines 68
*Recent Uses of the Gas Engine, by Chas. H. F. Lubcke 33
Source of Luminosity in the Welsbach Mantle, by Carlton Lambert, M. A. 50
‡The Future of Non-Luminous Gas 45
*The Westinghouse Gas Engine, by Edwin Ruud 62

Historical

The Heretofore Unpublished Facts of the Pomona Case, by C. G. Baldwin 23
‡To Stanley Belongs the Credit 14

Hydraulics

*Cut-Off Nozzles at the Aspen Power House, by C. E. Doolittle 19
†Determining Water Wheel Efficiencies 96
Electric Utilization of Water Falls 35
*Rainfall in San Francisco from 1849 to 1898, by Marsden Manson, C. E., Ph. D. 9
‡The Value of a Water Power 14
Water Powers in Southern California, by C. G. Baldwin 5

Miscellany

§American and Foreign Patents 68
‡An English Method of Drying Transformers 97
Electroplating Prevents Fouling of Hulls 65
§Filing Cabinets and Business Furniture 68
Graphite from Acetylene 14
§Ice Making and Refrigerating Machinery 68
§John M. Klein Electrical Works 68
‡Mistakes Will Happen 31
‡Qualifications of an Engineer's Assailants 96
§Windmills, Pumps, and Gas Engines 68
World and *Engineer* Combined 61

PAGE

Illumination

§*Enclosed Arc Lamps of New Design 19
†Evolution, Not Revolution, is at Hand 60
†Gas vs. Electric Lighting 13
§High and Low Frequency Alternators 51
‡Inefficiency of Incandescent Lamps 61
§Long Burning Arc Lamps 68
Luminosity of a Nernst Lamp is Deceptive 77
Nernst's Electric Lamp, by James Swinburne 27
No Standard of Illumination 65
One Candle-power per Watt 59
‡San Francisco Ranks Third 31
The Lesson of a Municipal Failure, by J. H. Stallard, M. B., London, etc. 65
*The Monterey and Pacific Grove Lighting Plant, by Harry J. Bean, A. B., E. E. 37
§Thomson Recording Wattmeters 68
§Transformer Design and Operation 68
‡Two Illogical Conditions 31
†We Are But Finite Beings 30

Literature

"Commercial Cuba," by W. . Clark 35

Mining

§An Opportunity for Prudential Investment 51
‡Breaking Down the Barriers of Conservatism 45
*§Double Drum Hoist and Electric Motor 51
‡Mining is Its Element 61

Personal

Benjamin, Edw. H. 35
Briggs, W. W. 35
Brooks, J. W. 35
Clark, W. J. 11
Coffee, A. J. 35
Hunt, A. M. 35, 92
Knight, C. S. 59
Meredith, Wynn 35
Sprout, Sydney 35
Theberath, T. E. 92

Physics

Measurement of Low Temperatures, by Walter H. Dickerson, M. E. 81
*The Wehnelt Electrolytic Interrupter, by A. Blondel 100

Pneumatics

Liquid Air as a New Source of Power 95

Steam

§A Remarkably Efficient Water Tube Cleaner 36
A Test of California Fuel Oil, by A. M. Hunt, M. E. 24
‡Cost of Steam Power 31
Development of California Oils 25
Steaming Value of California Fuel Oils, by Geo. H. Larkin 24
§Stirling Water Tube Boiler 68
The Trend of Central Station Design, by Bion J. Arnold 39

Transmission

†"All That Glitters is Not Gold" 12
†An Inexcusable Failure 79
*Calculating Transmission Conductors, by Prof. George Forbes, F. R. S., M. I. C. E. 97
‡Phase Influences on Rotary Converters 31
*Regulation by Leading and Lagging Currents 28
Synchronous and Induction Motors, by Charles F. Scott 77
*The Ferraris-Arno Phase Transformer 81
*The Kootenay-Rossland Power Transmission, by Geo. P. Low 69, 86
†The Limits of Electric Power Transmission 44
‡The Mount Whitney Transmission 46
†The New Transmissions of the West 78
*Three-Phase Transformer Manipulation, by A. J. Bowie, Jr. 21

Transportation

‡A General Formula or Train Resistance 61
‡*Cassier's* Electric Railway Number 46
†Popularizing Automobiles in Europe 30
Railway Electrolysis Popularized (Communicated) 42
*Rotary Converters in Railway Work, by Louis Bell, Ph. D. 15
§The Modern Roundhouse Turntable 68

THE JOURNAL OF ELECTRICITY.

VOLUME VII. SAN FRANCISCO, JANUARY, 1899. NUMBER 1.

Water Powers in Southern California.

BY C. G. BALDWIN.

The history of water-powers in southern California has been short, somewhat extensive, and in general, unsatisfactory. In view of these facts and of the further fact that other undeveloped powers remain, and are being industriously promoted, a comprehensive statement of all the essential considerations which relate to such enterprises seems eminently proper, and this brief discussion is written by one who has had the valuable experience of disappointment. He has learned some things from failure. The following pages are for the benefit of those who own stock or bonds of such companies or who contemplate such investments. The aim is to make the layman intelligent upon the subject so that he may be in a position to use experts rather than be helplessly dependent upon them. The suggestions and information herein contained would have saved several men in southern California many thousands of dollars of bad investments made within the last few years. Gentlemen have confessed to me that they relied unintelligently and helplessly upon the engineers of promotors.—C. G. B.

I.—CAUSES OF DISAPPOINTMENT.

IN all cases the main, and substantially the only difficulty, has been shortage of water. Companies have based their expectations upon far more than the lowest water they have had during dry seasons.

The first plant built in southern California, using a high potential and long distance transmission, was that of the San Antonio Light and Power Company, of Pomona. Indeed, no commercial plant anywhere had, up to that time, used over a 4000-volt current or transmitted over fourteen miles, while this plant boldly attempted a thirty-mile transmission and a 10,000-volt current. Electrically it was far more successful than the highest hope of the Westingnouse company, which made the installation. It is due to Mr. William Stanley, of the Stanley Electric Manufacturing Company, of Pittsfield, Mass., to say that he approved the plan which I presented to him and agreed to install the plant if the Westinghouse company and the Thomson-Houston company refused to do so. This proposition of Mr. Stanley's led both companies to reconsider their refusal to undertake it and the plant was put in under the direction of Mr. L. B. Stillwell, now of the Niagara plant. From the beginning, one man on duty in the mountains regulated the incandescent lamps of San Bernardino thirty miles away so perfectly as to compete on equal terms with the local steam plant, and at the same time he controlled the arc lights and incandescents of Pomona, thirteen miles in the other direction. The line insulation was wholly satisfactory in all weathers. The cost of installation conformed very closely to estimates made, and the current expenses proved considerably less than had been forecast. Thus a satisfactory beginning was made. Prices for lights, though low—$8.00 for arc lights and 50 cents to 80 cents per incandescent lamp per month—showed a good profit and the business grew. The enterprise has proved, however, quite disappointing to stockholders. The estimate for water was placed at 1000 miners inches, or 9000 gallons per minute. The record of the preceding seven years showed the lowest water of no year less than 700 miners inches, and the very lowest water of one year was over 1200 miners inches. The enterprise was built upon 1000 miners inches and a fall of 400 feet. This would furnish about 900 horse-power gross, and deliver for use about 600 horse-power. At a cost of less than $150,000 and with a current expense of less than $450 per month, this would furnish a good income. But alas for our hopes! The water dropped as low as 230 miners inches two years ago and considerably lower this lowest year! A steam plant added to the investment, and fuel expenses have eaten up profits. Having "promoted" this enterprise, I know the facts to my sorrow. Experience goes to show that the safe way to estimate your product and your business is with some distinct reference to the output of lowest water in very low years, if not the lowest year. During the last five years the water has run much below one-half our estimate of 1000 miners inches.

The most successful water power in southern California thus far in operation* is the one located on Mill Creek about two miles below its mouth, and about seven miles from Redlands—the Redlands Light and Power Company. Their fall is 510 feet and the very lowest water this year was just about 400 miners inches. The three-phase system has permitted a perfect motor service. Their business has been large and productive. The use of oil has cut a large figure this year, however, and has proved a great disappointment to those who depended upon them. The company had made large contracts at very low prices—not much more, in some cases, than one-half the cost of fuel at their power house. In spite of this experience the writer believes, and has good grounds for the belief, that an inside view of the books of the Redlands company will show a very fair investment, and its plans to increase its output to meet its demands are definite and entirely feasible. Its stock has paid dividends and is at par. Its patrons must be patient and suffer shortage and inconvenience in a dry year in return for the large advantages heretofore enjoyed and likely to be enjoyed with greater certainty hereafter. Here again the low water and nothing else was the cause of loss.

---

* This was written before the transmission of the Southern California Power Company began operations.—ED.

The latest electric transmission plant that has been placed in operation has suffered the greatest disappointment, being able to deliver less than 200 horse-power this summer on a large investment of capital. With the most perfect machinery and no unfortunate experience in unexpected cost of their hydraulic work, the disappointment lay wholly in the amount of water. Many undeveloped plants will never be developed because the series of dry years, and this dryest year in the last nineteen, have shown that they cannot produce an amount of power which will justify the investment.

II.—FOUR VITAL QUESTIONS.

There are four vital questions to be asked in the case of every water-power, and only four.

How much water at lowest? How much fall? Cost of development per horse-power? Market for power? We will discuss them in order.

In fixing the proper estimate of the water, it is exceedingly desirable to know the very lowest record. This it is oftentimes difficult to get. Traditional stories of dry creek beds, from the oldest inhabitant, are not satisfactory. It is one of the advantages of the past six years of comparatively dry weather that we can get at pretty exact figures from the weirs of the irrigating companies, and every layman should know how to measure a weir himself. It is unwise to trust the answers which inquirers receive from interested parties. Sometimes the weir will be purposely constructed to deceive, a very easy matter if a stake, driven in the water behind the weir, is depended on. Not infrequently the person who gives you the information does not know how to figure out the amount and is himself deceived. Often he is instructed to tell no one. The reputation of a water system may suffer from too exact knowledge as to lowest water. I was lately informed that a stream which I had measured as 525 miners inches was "about 800 miners inches." That word "about" covers a wide area with many men. Engineers are not all reliable. A gentleman brought me a report of an engineer upon a stream with which I was somewhat familiar, showing about 3000 miners inches on a certain day in October, of a very dry year. I knew that the lowest water that year was far below 500 miners inches, and concluded that the engineer must have taken his measurements immediately after a storm. On looking up the records of rains I found that such was the case! You must know your engineer in the case of a water-power and be no more trustful than in the examination of a gold mine. Our hard experiences justify the utmost care in finding out the water supply. A weir can be set in small streams in a few minutes, or at most a few hours, and its measurement will limit the word "about" to a very narrow area. With a cut in a board six inches deep and four feet wide (the edges beveled carefully on the side down stream so as to furnish no surface to retard the water in passing over) you can measure over 200 miners inches; for larger amounts make the cut wider and deeper.

The footnote* gives table showing the number of miners inches which each fraction of an inch in depth over the weir will give, and illustrates its working. The only thing left is to determine the depth. If you rely upon a stake set back of the weir about two feet and a little to one side in quiet water, you must determine that the top of this stake is on a level with the bottom of the weir and that the bottom is level. Then with dust upon a small stick it will be easy to measure the distance from top of stake to the surface of the water, the dust line showing how far the water rises. A method which permits you to easily correct your weir, if not set level, and saves driving and leveling the stake is as follows: Take a stick about 1½ inches square and 2½ feet long, straight edge on one side; put in a leg long enough to bring this straight edge above the water when the bottom of the leg rests on the bottom of the cut in the weir. Put in another leg at the other end, dip it in water and cover with dry dust. Now put your pocket level on the straight edge; hold the bottom of the leg at one corner of the weir and slowly lower the dusted leg into the still water back of the weir about two feet. When the bubble strikes the level, remove it and subtract the distance from the dust line to top of straight edge from the length of the leg on the weir measured to the back of the straight edge also. This will give the depth of water over the weir at that corner. Do the same at the other corner and take the half of the sum of the measurements. Thus you correct the error of the weir and save the setting of the stake, no easy matter without two men and a surveyor's level and rod. Be careful that the water flows smoothly over the weir from comparatively quiet water; if necessary, dig out a settling pond above the weir.

Having found the measurement of a stream in the middle of August, 1898, before any rains, and making the measurement yourself, or having it made by an engineer employed by yourself, you have taken the first and most important step, and in many instances this at once settles the question adversely. Streams reported to be "about 700 inches" have been found to measure only 125

---

* Weir measurement expressed in miners inches for each inch in width:

Depth in in.		⅛	¼	⅜	½	⅝	¾	⅞
1	.33	.39	.46	.53	.61	.69	.77	.85
2	.94	1.03	1.12	1.22	1.32	1.42	1.52	1.63
3	1.74	1.85	1.96	2.07	2.18	2.30	2.42	2.54
4	2.66	2.79	2.92	3.05	3.18	3.31	3.45	3.59
5	3.73	3.87	4.01	4.15	4.30	4.45	4.60	4.75
6	4.90	5.05	5.20	5.36	5.52	5.68	5.84	6.00
7	6.16	6.33	6.49	6.66	6.83	7.00	7.19	7.34
8	7.52	7.70	7.88	8.06	8.25	8.44	8.63	8.82

An example worked by this table would be as follows:

Weir 48 inches wide, water over weir at one corner 3⅛ inches; at the other 4½ inches; how many miners inches are flowing over the weir?

Method: $4\frac{1}{2}+3\frac{1}{8}\div 2=3\frac{11}{16}$ inches average depth. By table I find 3⅝ gives 2.30 miners inches, and 3¾ gives 2.42 miners inches, half way between gives $3\frac{11}{16}$ as 2.36 miners inches. Multiply this by 48 and you have 113.28 miners inches, the true result.

inches this dry year. Streams "as big as a man's body and very swift" I have found to be actually pools of water from which the real flow was only one or two miners inches. Photographs are of no value. In some way you must get actual and reliable measurements of the number of gallons per minute. One miners inch is nine gallons per minute.

The next vital point is the fall obtainable. These range in southern California, in plants now in, or projected, from about 400 to 2200 feet, and you do not need to depend upon an engineer to tell you what power the fall will produce. It is simply the weight of the water; one gallon weighs 8⅓ pounds, 100 miners inches or 900 gallons weigh 7500 pounds; if this moves 400 feet it is equal to 400 × 7500 pounds moving one foot in a minute, or 3,000,000 pounds. One horse-power moves 33,000 pounds one foot in a minute; therefore, 100 miners inches falling 400 feet will produce as many horse-power as 33,000 is contained in 3,000,000—90.9 horse-power. In other words multiply the water expressed in miners inches by 9 to reduce to gallons, by 8⅓ to pounds, and this amount by the fall in feet and divide by 33,000, and you have the theoretical horse-power. If this is to be used at a distance of ten to one hundred miles you must take away about one-third for losses. These will be as follows: Not less than 15 per cent. on water wheel, 5 per cent. of the balance in generator; 4 per cent. of the balance in "step-up" transformers; 4 per cent. to 10 per cent. line loss, depending on size of copper wire; 4 per cent. again in "step down" transformers, and 3 per cent. to 5 per cent. in distribution losses. In general, we say, count upon 66 per cent. of the weight of your water for actual use at the end of the wires. A fall of 2200 feet is entirely safe. Much above that head, it would be necessary to divide the fall and multiply the power houses. This means greater initial cost and greater current expense.

An inch of water falling 400 feet is worth for power just one-fifth as much as an inch falling 2000 feet. The fall is thus of great importance and can be quickly determined by your own engineer, or if it is a considerable fall an aneroid in your own hands will be accurate enough if the ground is traversed twice to correct any error caused by change of barometric pressure in the time the ground is traversed. Thus a day's time will determine the quantity of water and fall with sufficient accuracy to form a general basis of estimate of values. Such a trip would have saved many thousands of dollars in many cases of actual experience. Plans to use 2000 miners inches would not be made when half the year showed less than five hundred. You cannot guess water with sufficient accuracy nor elevation either. You need to know.

Now as to cost: There are all sorts of propositions. In some the hydraulic work will amount to $1000 for every horse-power you can deliver in a low year. Such a plant is worthless. In others, the cost will be perhaps as low as $30. Such a plant, other things being equal, is of great value.

The cost of a plant can be closely estimated. Enterprises such as the San Gabriel, the Southern California Power Company, operating in Santa Ana Canyon, the Redlands Light and Power Company, and the San Antonio Light and Power Company, of Pomona, have given experience from which most, if not all, of the elements needed can be accurately estimated. Elements of uncertainty lie mainly in tunnels. In estimating these, liberal allowance must be made for unforseen conditions of quick sand, very hard rock, etc. There is no excuse for any large error in estimates at this late date. Such errors are sometimes made purposely to encourage the beginning of work with insufficient capital with the hope, on the part of promoters, that once in, the capitalists will finish the plant to save their investment! This can always be avoided, and should be by insisting that before you invest, an engineer of reputation examine all the facts on behalf of the investors at their expense if report justifies the figures of the promotors, otherwise the promotors to pay the expenses. Another way is to ask some responsible financial institution to have its trusted experts make a report upon it upon same condition as to expense. All honest projects are willing to be investigated and court the light. All others should be exposed. With the bitter experiences of failure in this line, and after our dry years, the chances of deceiving an expert as to the merit of a project in which he has no financial or other interest are very remote.

No water power in southern California should cost for the hydraulic work, including power house and water wheels, over $250 per horse-power gross, and expect to make a profit against fuel-oil in most locations. If the hydraulic work exceeds $200 horse-power gross, it should be carefully considered; and by this I mean the amount of water being figured not over 70 per cent. more than in August, 1898. This is far lower than the lowest water of the average year, but it is none too low, for these dry years will come occasionally.

Assume water to be 170 per cent. of the lowest record of 1898, and then ascertain that the cost of your complete hydraulic work will be less than $200 per horse-power, theoretical, as shown by the weight of the water, or else raise a sharp question mark, for there are plants in southern California which, reckoned upon this plan, will run as low as $60 for complete hydraulic work, and while it is very unlikely that all the power needed can be furnished from southern California water powers, still a competitor can dictate terms and force a combination or a surrender, and with a margin of $140 per horse-power he has a great advantage. The cost of a delivered horse-power, net, reckoning water as above, should in no case exceed $400, and such a water power would be of doubtful value since less than $225 will deliver a horse-power net in some extensive plants.

We now come to the fourth and last element, the matter of market:

A water power should seek a market which is flexible as possible so that it may utilize somewhat more than the product of the lowest months in the lowest years. I doubt whether any service but that to mines can be made to pay unless full power installed is furnished for at least eight months in the year. No market should be sought, therefore, which cannot be supplied in nine years out of ten for at least eight months. It will not pay to install wheels and generators and distribution lines for more than this. In a rough way I would say that not over three times the lowest water of 1898 in any stream should be counted upon for any use at all. I know, however, that practice has been far less conservative, sometimes installing as many as eight times the actual highest production of August, 1898. Such a plan makes great duplicate plants necessary, and this makes competition of oil a very serious danger. Conditions must be very exceptional which justify eight times the lowest product of 1898. I would not today advise more than twice the installation which could be operated at lowest water this year, though this is rather extreme conservatism, especially if any considerable part of the business can be flexible.

In case of mines, the power company can afford to furnish at so low a price, compared with its cost by other methods, that it would be possible to furnish it for eight months in the year, and in one year in five, perhaps not over six months. Mines in southern California are paying from $14 to $22 per effective horse-power delivered to the shaft of their machinery. This can be furnished at so low a price as to secure the whole mining trade, especially if motors are furnished by the power company. Under these conditions there could be a distinct contract to withdraw with sixty days notice, and a water company can make close estimates sixty days ahead on falling water. Street car business and electric lighting, independent of steam duplicate plants, are not satisfactory for a water power unless they together aggregate but one-half of a full load, and the other half is of a kind to be cut down or cut off.

Pumping water for irrigation is good if conditions are favorable. Such users can be cut down somewhat as they can plan for a dry year and short water except in the case of a certain amount for permanent orchards. In case of some slight shortage, their system is still better than storage and free flowing waters which drop to one-half or one-third the average in such a year as 1898 has been. Thus a pumping system of irrigation, based upon twice the lowest water of this year, would suffer less than the other ordinary systems have suffered. This is still more true if such a system does not need to accomodate itself to the full shortage by reason of cutting off of mines and factories before their supply is cut down below a certain percentage. This should be agreed upon. Perhaps the very best field is the mining field alone. The high price of fuel there will always be high. Water powers near these fields can be developed upon lines less conservative than those enumerated above.

III.—COST OF POWER IN SOUTHERN CALIFORNIA.

To determine whether a water-power can secure a market at remunerative rates it is necessary to know what power costs the consumer; for unless the water power can furnish the power at a lower cost it cannot hope to succeed. It must supplant steam and gas engines, overcoming inertia by the force of financial inducements.

Counting fuel oil at $1.00 per barrel, large condensing engines can, under a steady load, produce power at the rate of $60 per annum, twenty-four hours' service. This can only be done in units large enough to nearly eliminate the labor item—not less than 2000 horse-power. A compound condensing engine of 200 horse-power capacity is running under such conditions as to produce power at the rate of $70 per horse-power for fuel and labor. This is the best small power plant I have found. Steam plants of 20 horse-power cost in no case less than $140 per annum per horse-power for fuel and labor. Gasoline plants of like capacity not less than $200. Distillate plants of 20 horse-power will require not less than $175 per horse-power in fuel and labor. It is not unusual to find a 10 horse-power plant costing $260 per horse-power. The most accurately reported power of this description, rated at 12 horse-power, has cost $217 per rated horse-power, probably $325 per actual horse-power, counting the year 280 days. The most reliable dealers in gasoline engines give two cents per hour per horse-power as the lowest rate which can be safely counted upon for fuel, and 1½ cents for distillate, gasoline being 12 cents per gallon and distillate 10 cents. Inquiry among users confirms these figures, though in many cases a larger cost is found and no well authenticated case of a lower cost. Labor is rarely found to cost less than $75 per month for 24-hour service with gasoline engines, and this is too low for long continued service. A few have operated for a short time with still cheaper labor. Using these elements it is easy to discover the cost of operating small plants.

To make a comparison on a larger scale: Assume two plants, one steam and the other hydraulic, used to distribute power over an area requiring 25 miles for distributing lines from the center of operation of the steam plant, and the water power 25 miles distant from such center, each capable of delivering 1200 horse-power to the motors used to pump water. Allow $1.50 per barrel for fuel oil delivered to the plant. With these assumptions the following table shows comparison between the two plants:

ORIGINAL COST.

	Steam.	Water Power.
Cost of Plant	$ 60,000	$130,000
Generators	27,000	32,000
Lines	12,500	38,000
Motors and Pumps	75,000	75,000
Total cost	$174,500	$275,000

ANNUAL EXPENSES.

	Steam.	Water Power.
Labor and Fuel	$113,000	$ 8,000
Interest and Depreciation	17,450	27,500
Total expense	$130,450	$ 35,500
Expense per horse-power	$108.71	$29.58

It is easy to see that at $108.71 per horse-power, such a steam plant will supplant all isolated plants of 20 horse-power or less, assuming electric motors requiring little attention with constant load and unvarying conditions.

Transmission

RAINFALL AT SAN FRANCISCO FROM 1849 TO 1898.*

BY MARSDEN MANSON, C. E., PH. D.

THE importance of the accurate recording of rainfall at numerous stations is becoming greater each year. This growing importance is due to the greater interests at stake, and to the increasing value of flood waters for diversion and storage; so that not only are these records valuable over agricultural and pasture lands, but over mountain areas. The conditions which control the rate of run-off from these areas are also vital, for upon this rate depends the damage by flood and the value of drainage water for industrial purposes. If the drainage area be stripped of trees and vegetation, and denuded of humus and soil, the rate of run-off is increased, the valleys below are subjected to floods of greater violence, and the streams dry up earlier in the season. A careful analysis of the rainfall of any part of California yields interesting and valuable results. To the farmer these studies are of incalculable value. To the capitalist they serve as guides in his investments in many industrial developments. To the civil engineer they form the basis of study for municipal and irrigation water supply, the dimensions and capacities of reservoirs and conduits, and of the intricate problems of drainage and utilization of waste waters.

The characteristic winter storms in the vicinity of San Francisco commence with a strong southeast breeze. During the progress of the storm the wind shifts to the south, southwest, and west or northwest. The barometer falls during the first and rises during the latter part of these wind changes. These phenomena mark the approach of an area of low barometric pressure from the northwest, and its passage eastward along a line north of San Francisco. These are the general features accompanying the rainfall of ordinary winters. The rainfall frequently extends as far south as 32° N., at which latitude it is from one-half to one-third that at San Francisco.

During summer the phenomena accompanying our winter rains decrease in extent, and retreat northerly some ten or twelve degrees, and California is south of the precipitation caused by the passage of an area of low pressure.

In certain winters, like that of 1876-7, or the one just passed, the character of the storms changes entirely. The change is radical, the phenomena are variable, and more like those accompanying the mild summer rains of Oregon and Washington.

It appears from a general study† of the subject that this difference in the character of the season is due to a shifting of the lines along which the areas of low pressure move to a more northerly route, or to a more restricted area of rainfall as the low approaches the coast and passes into the interior of the continent.

It also appears that the wet winters of California are due to conditions which cause these low areas to move on more southerly lines, and the areas of rainfall to have a correspondingly greater southerly extension.

In order to bring out the extent of these variations in winter rainfall the entire period of observation will be reviewed.

The rainfall at San Francisco has been quite accurately and continuously recorded since 1849. Up to 1870 the record was kept only by Mr. Thos. Tennent. Since that date it has also been kept by the United States Signal Service, and by the Weather Bureau.

The following table gives the monthly and annual rainfall, the totals and means from 1849 to 1898:

Table of monthly rainfall at San Francisco, Cal., 1849-1898, showing mean, monthly, seasonal and yearly rainfall for 49 years:

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Total.
													Inches
1849-50.	0.00	3.14	8.66	6.20	8.34	1.77	4.53	4.46	0.00	0.00	0.00	0.00	33.10
50-51.	0.33	0.00	0.92	1.05	0.92	0.54	1.94	1.23	0.67	0.00	0.00	0.00	7.40
51-2.	1.03	0.21	2.12	7.10	0.58	0.14	6.68	0.26	0.32	0.00	0.00	0.00	18.14
52-3.	0.00	0.80	5.31	13.20	3.92	1.42	4.86	5.37	0.38	0.00	0.00	0.04	35.30
53-4.	0.46	0.12	2.28	2.32	3.88	8.04	3.51	3.12	0.02	0.08	0.00	0.01	23.84
54-5.	0.15	2.41	0.34	0.81	3.67	4.77	4.64	5.00	1.88	0.00	0.00	0.00	23.67
55-6.	0.00	0.00	0.67	5.76	9.40	0.50	1.60	2.94	0.76	0.03	0.02	0.00	21.68
56-7.	0.07	0.45	2.79	3.75	2.45	8.59	1.62	0.00	0.10	0.12	0.00	0.05	19.99
57-8.	0.00	0.93	3.01	4.14	4.36	1.83	5.55	1.55	0.34	0.05	0.05	0.16	21.97
58-9.	0.00	2.74	0.69	6.14	1.28	6.32	3.02	0.27	1.55	0.00	0.00	0.02	22.03
59-60.	0.03	0.05	7.28	1.57	1.64	1.60	3.99	3.14	2.86	0.09	0.21	0.00	22.46
60-1.	0.00	0.91	0.58	6.16	2.47	3.72	4.08	0.51	1.00	1.08	0.00	0.00	19.51
61-2.	0.02	0.00	4.10	9.54	24.36	7.53	2.20	0.73	0.74	0.05	0.00	0.00	49.27
62-3.	0.00	0.40	0.15	2.35	3.63	3.19	2.06	1.61	0.23	0.00	0.00	0.00	13.62
63-4.	0.03	0.00	2.55	1.80	1.83	0.00	1.52	1.57	0.78	0.00	0.00	0.21	10.29
64-5.	0.01	0.13	6.60	8.91	5.14	1.34	0.74	0.94	0.63	0.00	0000	0.00	24.52
65-6.	0.24	0.26	4.19	0.58	10.88	2.12	3.04	0.12	1.40	0.04	0.00	0.00	22.93
66-7.	0.11	0.00	3.35	15.16	5.16	7.20	1.58	2.36	0.00	0.00	0.00	0.00	34.92
67-8.	0.04	0.20	3.41	10.69	9.50	6.13	6.30	2.31	0.03	0.23	0.00	0.00	38.84
68-9.	0.00	0.15	1.18	4.34	6.35	3.90	3.14	2.19	0.08	0.02	0.00	0.00	21.35
69-70.	0.12	1.29	1.19	4.31	3.89	4.78	2.00	1.53	0.20	0.00	0.00	0.00	19.31
70-1.	0.04	0.00	0.47	3.30	2.63	3.53	1.05	1.89	0.23	0.01	0.00	0.02	13.17
71-2.	0.00	0.07	2.81	14.36	4.00	6.90	1.59	0.81	0.18	0.04	0.01	0.00	30.77
72-3.	0.04	0.11	2.79	5.95	1.58	3.94	0.79	0.43	0.00	0.02	0.01	0.08	15.74
73-4.	0.00	0.83	1.16	9.72	5.66	2.21	3.36	0.90	0.66	0.14	0.00	0.00	24.64
74-5.	0.02	2.69	6.55	0.33	8.01	0.32	1.30	0.10	0.22	0.02	0.00	0.00	20.56
75-6.	0.00	0.24	7.27	4.15	7.55	4.92	5.49	1.29	0.24	0.04	0.00	0.01	31.21
76-7.	0.38	3.36	0.25	0.00	4.32	1.18	1.18	0.26	0.18	0.01	0.02	0.00	11.04
77-8.	0.00	0.65	1.57	2.66	11.97	12.52	4.56	1.06	0.16	0.01	0.01	0.00	35.17
78-9.	0.55	1.27	0.57	0.58	3.52	4.90	8.75	1.89	2.35	0.05	0.01	0.02	24.46
79-80.	T	0.78	4.03	4.46	2.22	1.87	2.08	10.06	1.12	0.00	0.00	0.00	26.63
80-1.	0.00	0.05	0.33	12.33	8.69	4.64	0.90	2.00	0.22	0.69	0.00	0.00	29.85
81-2.	0.25	0.54	1.94	3.85	1.68	2.96	3.45	1.22	0.21	0.04	0.00	0.00	16.14
82-3.	0.26	2.06	4.18	2.01	1.92	1.04	3.01	1.51	3.52	0.01	0.00	0.00	20.12
83-4.	0.42	1.40	1.60	0.92	3.94	6.65	8.24	6.33	0.23	2.57	T	0.04	32.42
84-5.	0.33	2.55	0.26	7.68	2.53	0.30	1.01	3.17	0.04	0.19	0.06	T	18.12
85-6.	0.11	0.72	11.78	4.99	7.42	0.24	2.07	5.28	0.37	0.01	0.23	T	33.22
86-7.	0.01	1.48	0.84	2.07	1.90	9.24	0.84	2.30	0.06	0.07	T	0.01	18.82
87-8.	0.29	T	0.99	3.34	6.81	0.94	3.60	0.11	0.38	0.27	0.01	0.01	16.75
88-9.	0.98	0.13	3.99	5.80	1.28	0.72	1.10	0.96	2.17	0.03	0.01	T	23.85
89-90.	T	7.28	2.99	13.81	9.61	5.16	4.73	1.18	1.07	0.10	0.02	0.00	45.86
90-1.	0.31	0.00	0.00	3.25	0.98	7.26	1.96	2.44	1.25	0.11	0.10	0.02	17.68
91-2.	0.77	0.04	0.56	5.62	2.42	2.90	2.85	1.39	1.86	T	0.00	0.00	18.41
92-3.	0.02	1.65	3.91	5.08	3.05	2.75	4.08	1.03	0.15	0.03	0.00	0.02	21.77
93-4.	0.21	0.16	4.18	2.25	5.99	2.69	0.60	0.50	1.31	0.56	T	0.00	18.45
94-5.	1.05	1.73	0.88	9.01	6.99	2.31	1.89	1.24	0.69	0.00	T	0.00	25.79
95-6.	0.77	0.11	1.78	1.43	8.14	0.28	2.85	5.16	0.72	0.00	0.04	0.09	21.37
96-7.	0.52	1.55	4.56	4.34	2.26	4.41	4.56	0.27	0.61	0.22	T	T	23.30
97-8.	0.10	1.70	1.05	1.22	1.12	2.13	0.24	0.19	1.44	0.19	0.00	T	9.38
98-9.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
1899-1900	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Totals	10.07	47.02	133.65	250.39	241.65	174.34	153.31	92.18	35.67	7.22	0.82	0.81	1147.13
Mean Monthly.	0.21	0.96	2.72	5.11	4.93	3.56	3.13	1.88	0.72	0.14	0.02	0.02	23.41
Mean Seasonal.		3.89 Autumnal rains			13.60 Winter rains			5.73 Spring rains			0.18 Summer rains		

In this period of forty-nine years the normal seasonal rainfall has been 23.4 inches. In the period under consideration there have been fluctuations in seasonal rainfall from 7.4 in 1850-51, to 49.2 inches in 1861-2. The mean seasonal precipitation for the entire period is 23.4 inches, the mean for each month and for each season of the year being given in the table. The entire period may be subdivided into five classes: 1—extremely dry, 2—dry, 3—average, 4—wet, and 5—extremely wet years. This subdivision is an arbitrary one (as would be any subdivision whatever), and the following classification is made: Extremely dry years, less than 14 inches; dry years, from 14 inches to 19 inches; average years, from 19 inches to 28 inches; wet years, from 29 inches to 35 inches; and extremely wet years, over 35 inches of rainfall. Based on this classification we have the following: The seasons 1850-51, 62-3, 63-4, 70-71, 76-7, and 97-8 have been extremely dry, the mean monthly rainfall being as follows: September, 0.14; October, 0.74; November, 0.89; December, 1.62; January, 2.38; February, 1.76; March, 1.31; April, 1.12; May, 0.59; June, 0.03; July, 0.00; August, 0.04; or an annual mean rainfall for these years of 10.8 inches.

The eight seasons of 1851-2, 72-3, 81-2, 84-5, 86-7, 87-8, 90-91, 91-2 were dry years, with an annual rainfall between 14 and 19 inches, the mean monthly distribution for these years being: September, 0.38; October, 0.62; November, 1.20; December, 4.86; January, 2.31; February, 3.46; March, 3.02; April, 1.41; May, 0.50; June, 0.09; July, 0.02; August, 0.01; or an average mean rainfall of 17.39.

The twenty-three years, 1853-4, 54-5, 55-6, 56-7, 57-8, 58-9, 59-60, 60-61, 64-65, 65-6, 68-9, 69-70, 73-4, 74-5, 78-9, 79-80, 82-3, 88-9, 92-3, 93-4, 94-5, 95-6, 96-7 were years of between 19 and 28 inches, with a mean monthly distribution as follows: September, 0.23; October, 1.00; November, 2.90; December, 4.08; January, 4.54; February, 3.08; March, 3.35; April, 1.98; May, 1.06; June, 0.11; July, 1.01; August, 0.01; or a mean seasonal rainfall of 22.37.

---

* Climate and Crops: California Section, U. S. Department of Agriculture, October, 1898.

† See a paper on "Importance of North Pacific Weather Stations," read by the author before the Science Association of the University of California, April 11, 1893.

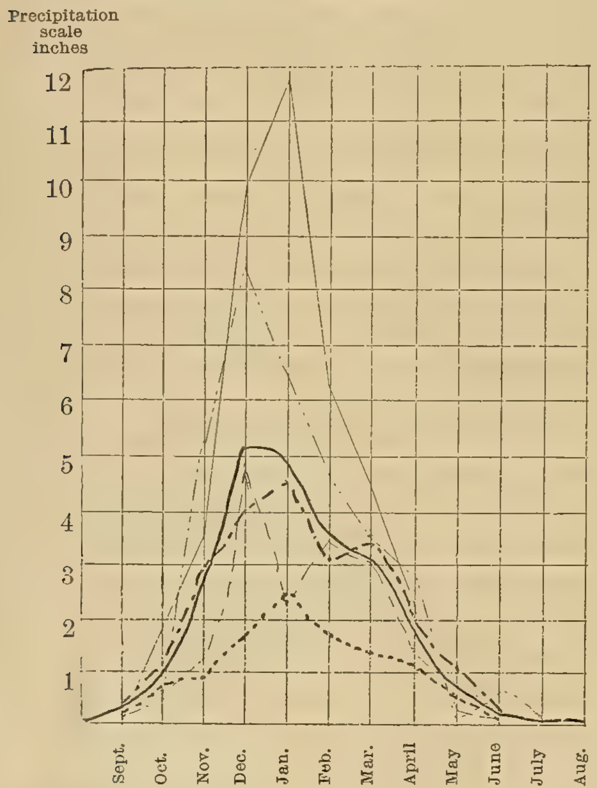
The seven years, 1849-50, 66-7, 71-2, 75-6, 80-81, 83-4, 85-6, were wet years, the extremes being 29 and 35 inches, with a mean monthly distribution as follows: September, 0.09; October, 0.81; November, 5.11; December, 8.30; January, 6.44; February, 4.62; March, 3.50; April, 2.65; May, 0.18; June, 0.46; July, 0.03; August, 0.01; or a mean seasonal rainfall of 32.21.

The five extremely wet years, having a rainfall in excess of 35 inches were: 1852-3, 61-2, 67-8, 77-8, 89-90. The mean monthly distribution of rainfall for three years was: September, 0.01; October, 1.79; November, 3.46; December, 9.98; January, 11.87; February, 6.27; March, 4.50; April, 2.13; May, 0.48; June, 0.08; July, 0.01; August, 0.01; the mean rainfall for these five extremely wet years being 40.89 inches.

The relation between each of these classes and of each class to the mean monthly distribution of rainfall for the entire period is shown on the following table:

Mean monthly distribution of rainfall for:	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Mean yearly rainfall for each group.
6 ex. dry years..	0.14	0.74	0.89	1.62	2.38	1.76	1.31	1.12	0.59	0.03	0.00	0.04	10.82
8 dry years......	0.38	0.62	1.20	4.86	2.31	3.46	3.02	1.41	0.5	0.09	0.02	0.01	17.39
23 average years	0.23	1.00	2.90	4.08	4.54	3.08	3.35	1.98	1.06	0.11	0.01	0.01	22.37
7 wet years......	0.09	0.81	5.11	8.30	6.44	4.62	3.50	2.65	0.18	0.46	0.03	0.01	32.21
5 extra wet years	0.01	1.79	3.46	9.98	11.87	6.27	4.50	2.13	0.48	0.08	0.01	0.01	40.89
Entire period..	0.21	0.96	2.72	5.11	4.93	3.56	3.13	1.88	0.72	0.14	0.02	0.02	23.41

These figures give the following diagram:



——— Normal curve.
-------- Extremely dry years.
— — — Dry years.
—-—-— Average years.
—-·-·-— Wet years.
——— Extremely wet years.

If these figures and the resulting curves yield any guide in forecasting seasons, we have the following: Both dry and extremely dry seasons are deficient in autumnal rainfall. In extremely dry years the greatest monthly deficiency occurs in December, and continues through the spring. In dry years the greatest deficiency falls in January, followed by a spring in which the departure from normal rainfall is light.

In years of average rainfall the maximum is in January, followed by a wet spring. In wet years the autumnal rainfall is heavy, followed by a maximum in December which continues above the normal through the rest of the winter and spring. In extremely wet years the maximum rainfall is in January, continuing well above the normal to April, and falling sharply below the normal in May.

These variations in the winter rainfall are primarily due to the changes in the position of the lines upon and along which the areas of low pressure originate and move in their course from the north Pacific into the interior of the continent. It therefore becomes important to know the causes and conditions controlling this shifting or restriction of the belt of rain distribution, for when these shall become known it will be reasonably possible to foretell whether a winter will be one of deficient, average, or excessive rainfall.

Since these storms approach from the west and move in from the north Pacific, all phenomena connected with their origin, course, and intensity, and even minute variations in these phenomena, become important. It is desirable, if possible, to ascertain where the moisture is evaporated which is precipitated on our shores, and whether there be changes in the locus of these areas; whether the variations in our seasonal rainfall be due to differences in air and sea temperatures, direction of winds, or in the position and intensity of barometric pressure over the north Pacific ocean, and the favorable and unfavorable combination of these and other factors. The agricultural products of California are becoming so important a factor in the world's markets that weather conditions affecting them are of great commercial value. It would not be possible to compute the value of a foreknowledge of what the general character of the season's rainfall was going to be. But it is entirely within the range of scientific investigation to determine in general what the conditions are, and to foretell within reasonable limits the probable amount of the seasonal rainfall, and this study merits the most thorough investigation and solution which science can devise.

Gas

ACETYLENE.*

BY PROF. VIVIAN B. LEWES, F. I. C., F. C. S.

II.

Up to the end of 1892 it was Willson only who made carbide on anything like a large scale, and nothing would ever have been heard of this material on a commercial scale had it not been that he, in attempting to get capital invested in his process, came across several men of sound, practical knowledge, whose business instincts led them to grasp the possibilities of carbide and acetylene. No sooner had these commercial possibilities been noised abroad than others began to try to make capital from them, but Willson continued his experiments on a commercial scale throughout 1892 and 1893 and formed a company with works at Spray, N. C., utilizing 2,000 amperes at 25 volts. By this time the manufacture of carbide was well launched. The reports of Mr. Frank H. Mason, American Consul General at Frankfort, point out that the carbide industry, so far as central Europe is concerned, is now in a transition stage, and that the conditions of supply and price are likely to be modified by the enormous increase in production which is now being arranged for. In Germany, Austria and Switzerland arrangements are being made for the utilization of 35,000 horse-power, and elsewhere in Europe an additional 18,000 horse-power is to be utilized in the manufacture of carbide.

---

*Abstract of a series of four Cantor lectures delivered to the Society of Arts, London.

MANUFACTURE.

In the manufacture of calcic carbide in the electric furnace, lime and hard metallurgical coke of the highest possible degree of purity are employed. A good working mixture is 100 parts by weight of lime with 68 parts by weight of carbonaceous material, and about 1-8 pounds of this is used for each pound of carbide produced. It must not be forgotten in computing the cost of carbide that lime of sufficient purity for the purpose is not only costly but difficult to obtain in large quantities.

It is found that as the ignot of calcic carbide is formed in the furnace, although the ignot itself consists of pure crystalline calcic carbide, it is nearly always surrounded by a crust in which the carbide contains a certain proportion of imperfectly converted constituents. This gives a lower yield of acetylene than the carbide itself, and in breaking up and shipping the carbide in air tight drums, the worst of this crust is, as far as possible, picked out and rejected. It is perhaps misleading to state the amount made per electric horse-power, as a certain amount of loss is of necessity, entailed during breaking and packing. For instance, I have found that while the furnace return was, practically, 0.504 pound per kilowatt hour, this amount was reduced to 0.406 pound per kilowatt hour when ready for shipment. It will be sufficient for practical purposes to state that the cost of material, labor and wear and tear of plant independent of the power used in the electric furnace, but inclusive of packing, will amount to from $15 to $20 per ton, according to locality, which, of course, entirely governs the cost of the materials used, while the cost of the electrical horse-power necessary for the conversion of the material will entirely depend on whether it is obtained from steam, gas engines or water power, the latter, in Great Britain, costing nearly $20 per horse-power per year.

The two principal processes utilized in making calcic carbide by electric power are the ingot process and the tapping process. In the former the coke and lime are finely ground and carefully mixed in the right proportions to suit the chemical conditions involved. The arc is struck in a crucible and the powdered mixture is allowed to flow in and partially fill the crucible. An ingot gradually builds up from the bottom of the crucible, the carbon electrode being raised from time to time, automatically or by hand, to suit the diminution of resistance to the shortening of the arc by the raising ingot, the latter being surround by a mass of unreduced material which protects the crucible from the intense heat. When the ingot has been made and the crucible is full, the latter is withdrawn and another substituted. The process is not continuous, but a change of crucibles takes only two or three minutes under the best conditions, and occurs but once in every ten to fifteen hours. The essence of this process is that the coke and lime are only heated to the point of combination, and are not "boiled" after being formed. In the tapping process a fixed crucible lined with carbon is used. The electrode is nearly as big as the crucible, and a much higher current density is employed. Fine grinding is unnecessary, as combination probably only takes place after the fusion of the raw materials, which mix more or less as liquids. The carbide is heated to complete liquifaction and tapped at short intervals. There is no unreduced material and the process is considerably simplified, while less expensive plant is required; but, on the other hand, the output in carbide per electrical horse-power per day is considerably less than in the ingot process, and it is only more economical when power is comparatively cheap.

Carbide of calcium, as formed in the electric furnace at a temperature of 2,700° C., is a beautiful crystalline, semi-metallic looking solid, having a density of 2.22, and showing a fracture which is often shot with irridescent colors. It can be unaltered in dry air, but the smallest trace of moisture leads to the evolution of minute quantities of acetylene, and gives it a distinctive odor. It is infusible at temperatures up to 2,000° C., but can be fused in the electric arc. When heated to a temperature of 245° C., in a steam of chlorine gas it becomes incandescent, forming calcic chloride and liberating carbon, and it can also be made to burn in oxygen at a dull red heat, leaving behind a residue of calcic carbonate. Under the same conditions it becomes incandescent in the vapor of sulphur, yielding calcic sulphide and carbon disulphide, while the vapor of phosphorous will also unite with it at a red heat. It is a compound of calcium 62.5 per cent, and carbon, 37.5 per cent.

Acted upon by water calcic carbide is at once decomposed, yielding acetylene and calcic hydrate. Pure crystalline calcic carbide yields from 5.5 to 5.8 cubic feet of acetylene per pound at ordinary temperatures, but the carbide as sold commercially is a mixture of the pure crystalline material with the crust which, in the electric furnace, surrounds the ingot, and which, of course, yields less gas, the two being blended together to yield an average of 5 cubic feet of gas per pound of carbide under proper conditions of generation. But, as we shall see later, the volume of acetylene to be obtained depends very largely upon the form of apparatus to be used, some giving 5 cubic feet and others yielding but 3¾ cubic feet with the same barbide.

The purity of the carbide depends entirely upon the purity of the materials used in its manufacture, but although only the purest materials obtainable are now employed acetylene nearly always contains minute traces of hydrogen, ammonia, sulphuretted hydrogen, phosphoretted hydrogen, siliciureted hydrogen, nitrogen and oxygen, and sometimes carbon monoxide and dioxide.

M. Gerard has succeeded in extracting minute diamonds from the residues left after treating calcic carbide with water, the labor entailed in the separation of which may be estimated when it is stated that it was necessary to treat no less than between 700 and 900 pounds of carbide in order to obtain diamond material weighing 0.154 grain.

STORAGE.

There is no more risk in the storage of calcic carbide than there is in storing any other inert material, provided that it is packed dry and warm in hermetically sealed drums, so as to render it impossible for it to come in contact with water or moist air. The real risk is in the removal or redistribution of the material, as, after opening the drum, it may not be again properly closed, and if the drum be left open in this condition in the moist air of an ill-ventilated cellar it is quite possible for a slow generation of gas to take place, and for an explosive mixture to be formed by its accumulation. All carbide stores should be thoroughly well ventilated and above ground, and when this is the case all danger is practically done away with. For the carriage of carbide it is important that not only should the drums be air tight, but that they should be of sufficient strength to resist the rough usage incidental to the handling of a heavy product. Where tins are used they should always be protected by an exterior wood case.

(*To be continued.*)

Personal

Mr. W. J. Clark has accepted the position of general manager of the Foreign Department, with headquarters in New York, succeeding Mr. Mazonet, who for five years has held the general managership, and who has piloted it from its small beginnings to its present position as one of the foremost departments of the company. Mr. Mazonet now becomes managing director of the Mexican General Electric Company in the City of Mexico. Mr. Clark now has charge of all commercial relations between the General Electric Company and all countries outside the United States, and his wide experience in foreign commercial matters peculiarly fits him for his new position. He has traveled through Europe, as well as in the Central and South American countries, and his familiarity with foreign methods and manners will stand him in good stead. His book, "Commercial Cuba," recently published is already generally acknowledged to be the standard authority on Cuban commercial affairs.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of
Electricity and Transmission of Power.

Official Organ of the Pacific Coast Electric Transmission Association.

Subscription invariably payable in advance. Terms—Domestic, One Dollar per Year; Foreign, Two Dollars per Year. The trade supplied by the San Francisco News Company. Advertising rates furnished on application.

GEO. P. LOW, : : : Editor and Proprietor

PUBLICATION OFFICE:
320 CALIFORNIA STREET,
ROOM 14.

Address all communications to
Editorial rooms, 427 TENTH AVE.
Telephone, "Steiner 627."

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME VII JANUARY, 1899 NUMBER 1

EDITORIAL.

"ALL THAT GLITTERS IS NOT GOLD."

Considerable space is devoted in this issue to a discussion of some phases of a problem that has been by far the most serious that has ever confronted electrical transmission interests in California, and now that the difficulties which it presented have for the nonce been averted or surmounted, as each case may be, and as its perplexities have worn themselves from the present into the past, it is fitting that the trying, if not racking, experiences of the season just closed should impress their lessons so strongly as to most effectually prevent for all time the recurrence of such conditions as have of late confronted most California transmissions with sternness. This problem is simply that of water supply, and its seriousness is due to the facts that water power plants can generate no power without water, and that precipitations from the reservoirs of Heaven are not controlled or even influenced in the slightest by the penalties inflicted upon transmission corporations for broken power contracts; corporations are proverbially soulless anyway, hence why should the gods bother about their well being? When the "oldest inhabitant" sagely shook his head and said: "That river war'n't bigger nor a tiny leetle creek in '51," the promoter of the new transmission enterprise branded him as a fossilized obstructionist or a degenerated prevaricator. But the summer of '98 proved him to be neither and the shake of his head was a forewarning which some have failed to heed to their own sorrow, as well as to the financial disappointment of their associates.

The leading article in this issue brings these facts out strongly, and its tenor is confirmed by the official record of precipitation in San Francisco appearing on another page. While the subject of Professor Baldwin's discussion is confined to southern California, it might have been more general in character, even to the extent of including practically all California transmissions, without shooting wide of the mark. So far as the writer is aware, the only large transmissions of great commercial importance in northern California that have not felt the pinch of the late drouth materially are those on the Yubas. The Nevada county plant forestalled the prospective shortage in water due to drouth and greatly increased business by increasing the head of water from 300 to 800 feet; the South Yuba company had augmented its output by the installation of the new power house at Auburn, thus enabling it to meet the emergency; but the North Yuba or Marysville plant alone holds the enviable record among transmissions in northern California of not only being prepared for every emergency without extra preparation but, at the same time, of having thousands of horse-power in water flowing to waste over its dam throughout the entire summer. It is a mystery where this water came from during a season of snowless mountains and thirsty ravines. The Kern river, too, has maintained considerably more than sufficient water to meet the demands of the Bakersfield transmission, but the Folsom and Fresno transmissions fell into bitter extremities—the former finding it necessary to install a 600 horse-power steam plant, and the latter finding its capacity reduced to one-third of the normal. Had the drouth occurred a year later Fresno would have been able to have withstood it, for the great impounding reservior it has been building for many months would then have been completed. Folsom finds the storage capacity of its great dam to be largely a myth because the dam impounds mud and slickens to the exclusion of water, and it has also found, it is said by those who are in a position to know, that the recently installed auxiliary steam plant produces electrical energy at a materially lower cost per kilowatt hour, investment and all fixed and operating charges considered, than does the transmission plant under similar conditions. But this should not be surprising when the enormous cost of water development, as well as the pioneering nature of the plant is considered.

The title of Prof. Baldwin's article is therefore unnecessarily restricted, and the unwelcome fact is that in the matter of shortness of water supply during 1898 each section of the Golden State may commisserate with the other. But as there are exceptions to the general order of drouth in the northern portion, other exceptions, notably the Southern California transmission, stand out prominently in southern California. The Redlands plant was the first to accept the inevitable order of things, which makes it imperative that southern California transmissions, as a class, should provide auxiliary generating stations as part of the original investment, and the sooner other transmissions whose contract loads exceed the delivered power available from the minimum flow of '98, follow the lead thus wisely made the more quickly will their recovery from the set-back of last year be effected. Auxiliary plants are inseparable to any transmission relying upon the water power of a stream of uncertain flow, and even though such auxiliaries lie idle fifty weeks in the year they are still indispensable, cost what they may. In truth, the cost of its auxiliary plant represents the penalty the transmission must pay for being dependent upon an uncertain water supply.

Whether or not an auxiliary plant is an essential adjunct to a water power transmission depends therefore upon the ratio existing between the minimum water supply and the contracted load it must carry at all hazards, but so great is the strife for business that it is not venturesome to state that the station manager will invariably load his plant, if possible, "up to the muzzle," as the saying is, without more than a passing thought, if that, bestowed to the consideration of that "possible dimly distant," or perhaps "too-remote-for-present-consideration" time when the cycle of the period of drouth shall again roll around and the plant will again be face to face with the stern reality that water power plants without water have only a junk value for the time being. Water power is not infallable; even the falls of the Willamette, the finest water power in the West, have been obliterated by the backing up of the waters of the Columbia river to the height of the water of the Willamette above the falls.

The four vital questions in Prof. Baldwin's article are most pertinent, and the discussion of them given brings out some fundamental points which are sometimes clothed in ambiguity, in a simple yet forcible way. It is feared, however, that serious exception will be taken to the estimates of cost given in Part III for the generation of power in southern California. Gas engine men, for instance, will maintain almost to a unit that the fuel consumed in gasoline engines will not cost to exceed one cent per horse-power-hour, while in steam engine practice it will be contended that $50 per horse-power is an unwarrantedly high estimate of cost for a 1200 horse-power plant, and that the item of labor and fuel for the same would be much nearer correct were it $65,000 instead of the $113,000 given. But it must be borne in mind that the assumptions are vaguely stated and that an equitable analysis of the figures given is therefore impossible. It is regretted that no approximation can be given of the cost of any large southern California power transmission.

The largest, best and most constant water power in southern California is that of the Southern California Power Company on the Santa Ana river, and trustworthy advices state that the minimum flow at its power house during the summer of '98 has been the equivalent of about 2000 horse-power delivered at Los Angeles continuously, *i. e.*, 24 hours per day. This places the southern California plant well towards the front rank of those Pacific Coast transmissions that have become noteworthy for the permanence and reliability of their sources of water supply.

But what is to come of the agitation opened up by the memorable drouth of 1898? Simply this: Better engineering, a deaf ear to the statements of promoters so far as they bear on matters of engineering fact; a more thorough investigation into the merits of steam plants and gas engines as producers of power in competition with water power transmission plants, and finally a gradual uplifting of the veil of enchantment which has caused the spirit of capital to look with favor upon every scheme for "the utilization of nature's forces" through the mountain stream, the water wheel, the dynamo and the electric transmission line. In reality there is no magic art in the legitimate electrical business, it stands on its own feet, from whence it must fight its own battles alone and unsupported, and the only question for it to decide is: Given a fitting market, wherein may be found the cheapest and most reliable means for delivering electrical energy therein. Three methods of doing this are or may be available: water power and transmission, steam and gas engines.

Throw off the fascinating spell that the beauties of electrical transmission has cast about you, come right down to hard, cold business principles and weigh the case presented by each locality solely on its merits without regard to predilections. Had this been done in the light of the knowledge of to-day and had there been followed the conclusions that now would have been drawn, the list of transmissions would not be quite so long as it is, and the value of the steam plant, particularly on tide water, would be by no means so lightly held. Great minds, too, have been at work for years on the development of the gas engine in large units and the fruits of their labors should soon be at hand. The efficiency of gas engines is far higher than that of any other form of prime mover, and the advent of its perfected type will be a boon of incalculable value to the electrical industry, for, come what may, electrical distribution will always hold a royal sway over all other methods.

GAS VS. ELECTRIC LIGHTING.

Gas and electric corporations meet at least on two common levels, namely, those of supplying artificial light and motive power, and leaving aside all questions of public preferences except that of lowest cost, it is inseresting to take up the thread of argument advanced by *The Gas World*, (Vol. XXIX, page 922,) which states a fair case in assuming first, that the public wants lights, and, second, that it wants this light at the lowest cost. It has been claimed by "electrical prophets," quotes our valued contemporary, that "within a very few years electrical energy will be generally sold at 1½d. per unit." or at the rate of 3 cents per kilowatt hour. We of the Pacific Coast know that in the far west the general or average cost of generation and delivery to the bus-bars will not begin to approach the low cost of 3 cents per kilowatt hour with present appliances, whether in steam or transmission practices, although in very few exceptional instances the low rate given has even been made yet lower.

Leaving this point, our contemporary then examines into the probabilities of electricity "at 1½d. per unit," securing all the lighting business. Electrical energy at this price means that 250 candle-hours can be obtained for 3 cents, assuming an efficiency for incandescent electric lamps of 4 watts per candle, or if an efficiency of 3 watts per candle be assumed, 333 candle-hours in incandescent electric lighting would cost 3 cents. It is claimed that an efficiency of 20 to 25 candles per cubic foot of gas have been attained in the newest incandescent gas burners, or Welsbach mantels. Prof. Lewes, however, states that 17 candles per cubic foot is a good workable figure, according to which 19.6 cubic feet of gas will be required to give the 333 candle-hours obtained from one kilowatt of electrical energy. Throwing in the odd 0.4 cubic foot for gas consumed by the by-pass and the consumption of an even 20 cubic feet will be obtained, In England the average cost of gas is 2s. 6d. per thousand cubic feet, and the cost of the gas light will be 0.6d. (1.2 cents) against 1½d. (3 cents) for electricity, in other words, electric will still be two and one-half times as expensive as gas light according to the price of gas in England

This very rational mode of bringing out a comparative estimate of costs between lighting by gas mantels and by incandescent electric lamps grows in interest the further it is carried, and to localize it, in San Francisco 3.6-watt lamps are ordinarily used, while about the lowest rate at which electrical energy can be obtained is 7 cents per kilowatt hour. On this basis 1000 watt-hours of current will deliver 277 candle-hours of light, which, as it costs 7 cents, means that one cent's worth of current will give 39.6 candle-hours. Turning now to the other side, illuminating gas costs $1.75 in San Francisco, or for one cent a trifle over 5.7 cubic feet of gas will be delivered. Applying this gas to a Welsbach mantel, which Prof. Lewes states to have a lighting efficiency of 17 candles per cubic foot of gas, it is found that the cent's worth of gas will give 96.9 candle-hours against the 39.6 candle-hours which are obtainable from electricity by incandescent lighting. To meet $1.75 gas on the common level of equal cost per candle-hour, electricity will have to be sold at the rate of about 2.7 cents per kilowatt-hour. With gas at $1 per thousand the electrical equivalent will be 1.6 cents per kilowatt hour.

If electric lighting interests will persist in ranking gas as an enemy it is for their well-being that they should not underestimate the fighting qualities of their quondam antagonist; if they are wise they will be quick to recognize the extraordinary efficiency of gas for lighting and heating purposes, and will, as these columns have so often urged, hasten to make an ally of so valuable an agency. Gas and electric lighting are sister sciences—not inherently antagonistic industries.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

TO STANLEY BELONGS THE CREDIT.

Prof. Baldwin makes a valuable contribution to the history of electrical transmissions when he states in the leading article of this issue, in reference to the San Antonio Light and Power Company of Pomona, Cal., which is the pioneer 10,000-volt transmission of America, that "electrically it was far more successful than the highest hope of the Westinghouse company which made the installation. It is due to Mr. William Stanley, of the Stanley Electric Manufacturing Company of Pittsfield, Mass,, to say that he approved the plan which I presented to him, and agreed to install the plant if the Westinghouse and Thompson-Houston Company refused to do so. This proposition of Mr. Stanley's led both companies to reconsider their refusal to undertake it, and the plant was put in under the direction of Mr. L. B. Stilwell, now of the Niagara Company."

It has always been supposed that the bold use of 10,000 volts on the famous Pomona plant was due to the progressiveness of the Westinghouse company, but the glory it has worn so long loses its lustre in the light of Prof. Baldwin's statement. That it bears the imprint of authenticity is not to be doubted, because of Prof. Baldwin's worthy name and the fact that he has been the president of the San Antonio Light and Power Company from its inception.

* * *

THE VALUE OF A WATER POWER.

Apropos of the subject matter of the leading editorial of this issue, which might with equal propriety have been under the above caption, it is of advantage to note that a current number of the *Mining and Scientific Press* says:

> The value of a water power depends upon a variety of elements; numerous conditions may reduce its value. The essential points to be considered are as follows: Quantity of water during a dry year; uniformity of flow during the year, considering the storage capacity, natural and artificial; head of fall; conditions which fix the expense of building dam and canal, and flowage of land; conditions which affect the cost of foundations for buildings; geological conditions which determine the permanency of the fall; freight charges for fuel, supplies, raw materials and finished product; how much low-pressure steam can be used for heating purposes, and whether exhaust steam can be used for those purposes; if water is needed for other purposes than power, and in what quantities; the greater uniformity of speed with steam than with water power. The value of a variable power is usually very little if its variation is very great, unless it is to be supplemented by a steam plant. It is of value then only when the cost per horse-power for the double plant is less than the cost of steam power under the same conditions for a permanent power. The value of a developed water power is usually as follows: If the power can be run cheaper than steam the value is that of the power, plus the cost of plant, less depreciation. If it cannot be run as cheaply as steam, considering its cost, etc., the value of the power itself is nothing except in connection with possibilities in the direction of electricity or compressed air; but the value of the plant is such a sum as could be paid for it new, which would bring the total cost of running down to the cost of steam power, less depreciation. That is, it is worth just what can be got out of the plant, and no more.

GRAPHITE FROM ACETYENE.

The *Gas World*, London, states that Herr Bergmann finds that he can make beautiful graphite powder in quantity by oxdizing acetylene under pressure:

$$C_2H_2 + O = C_2 + H_2O.$$

He exposes acetylene along with peroxide of hydrogen to a temperature of 150° C., under a pressure of five atmospheres:

$$C_2H_2 + H_2O = 2H_2\ O + 2C.$$

The graphite may be filtered off. The same treatment applied to carbide of calcium results in a mixture of lime and graphite which can be separated by dissolving the lime in an acid and filtering.

"Your San Gabriel article is most interesting and accurate."—H. P. Reed, Los Angeles, Cal.

Transportation

ROTARY CONVERTERS IN RAILWAY WORK.*

BY LOUIS BELL, PH. D.

ALTERNATE CURRENT CONVERSION.

IT is the purpose of this article to explain what the rotary converter is, how it operates in practice, and under what circumstances it becomes economically available for railway work. For the general purpose of electric power transmission we have at present to depend on alternating currents, while nearly all the railway work of the world is by continuous current motors. Hence, to render transmitted energy available for the purpose in hand, it must be represented by continuous current derived in some practical and economical way from the alternating current. In the first place, one can utilize the alternating current in a suitable motor and thence drive a continuous current generator; second, one can rectify the current by a commutator driven by a synchronous motor; and finally, the alternating current can be changed to continuous current by the rotary converter. The first method involves the driving of two machines and adding the losses therein, a process obviously not of the highest efficiency, although sometimes advisable. On the other hand, to rectify alternating current by a commutator, while very highly efficient, brings in certain grave inherent difficulties which have never yet been successfully surmounted on any considerable scale. Chief among these difficulties is destructive sparking, due to the fact that it is practically impossible to so time the revolution of the commutator that the brushes shall pass from one segment to the next, thus rectifying the current, at the moment when the alternating current is passing through zero, and when there is, simultaneously, no difference of potential between the segments.

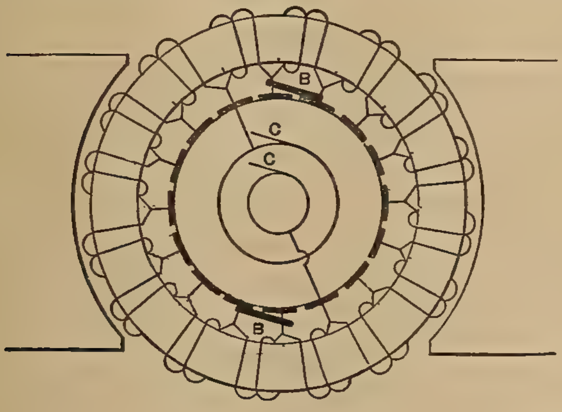


FIGURE I.—CONNECTIONS OF SINGLE-PHASE ROTARY CONVERTER.

On a small scale one can work a commutator so that both current and potential difference will be small when the brushes pass to the next segment, and so the sparking will be small, but the moment one deals with large currents and considerable voltages, that is, with large outputs, the sparking becomes destructive, particularly if the load changes rapidly. Thus, while synchronous commutators have proved fairly successful in small units, say of five to twenty kilowatts, for charging storage batteries and the like, they give very little promise of success on the scale required for railway work.

Now the rotary converter is an apparatus for cummuting alternating current under the same conditions that exist in the armature of an ordinary continuous current generator. We must remember that, fundamentally, all armatures generate alternating current, and that the sole function of the ordinary commutator is to so reverse the connections of the armature with respect to the external circuit that the current delivered to the latter shall be uni-directional. This commutation is done piecemeal, as it were, each individual armature coil being reversed in connection as it passes under the brush, so that the reversal deals with only a small portion of the total voltage—a few volts or even a fraction of a volt. We all know what trouble from sparking ensues when the voltage between commutator segments is too great.

Now the commutator neither knows nor cares what is the source of the current with which it deals—whether it is being generated in the armature or fifty miles away—so long as it is being delivered to it in the systematic way for which it was designed. Therefore, if just such alternating current is delivered to the armature as the latter was designed to deliver to the commutator, the process of commutation will go on in the regular way. And this is the essence of the rotary converter; it is a dynamo adapted to receive from an external source and to turn over to its commutator just such alternating current as it would necessarily generate if driven by its own engine.

SINGLE-PHASE ROTARIES.

Figure I gives a clear idea of the connections which would be found in a simple single-phase rotary converter. The armature there shown in diagram is a Gramme ring with sixteen armature coils and the same number of commutator segments. In addition to the commutator the armature is provided with two collecting rings *C C*, permanently connected to two diametrically opposite points of the armature winding. Now if the fields pertaining to this armature were excited and the armature were driven by a pulley, it would evidently produce continuous current if an external circuit were connected to the regular brushes *B B*. Similarly if these brushes were disconnected and the circuit were connected to the brushes bearing on the collecting rings *C C*, we should get an alternating current, for there would be no commutation and the current in each half of the armature would be reversed at each half revolution, that is, at each pole. If the speed of the armature were 1500 revolutions per minute, there would be in the resulting alternating current 3000 reversals per minute, amounting to twenty-five complete cycles per second, which is the frequency employed in the great Niagara plant.

We may thus consider that every continuous current armature generates within its coils an alternating current which has a definite frequency dependent on the number of poles and the revolutions per minute. We may commute this current or not, as we please, but it is always there and ready to be used if we put on collecting rings and take it out. The higher the speed and the greater the number of poles, the greater the intrinsic frequency of the machine. With four poles and 1500 revolutions per minute, the frequency would be fifty cycles, and in general for any machine it is, in cycles per second

$$\frac{\text{Number of poles} \times \text{r. p. m.}}{120.}$$

PRINCIPLE OF OPERATION.

Now suppose that we send into the armature of Figure I, through the rings *C C*, an alternating current of twenty-five cycles per second, after spinning the armature up to 1500 revolutions per minute. By so doing we have converted the machine into a synchronous alternating motor, and it will fall into step with the generator and run steadily along like any other alternating motor. Its speed will be 1500 revolutions per minute, and the current in its armature will reverse precisely as if it were being generated therein instead of arriving from the outside. The fields in this case would have to be excited from some external source.

While the motor is running in this wise, what will happen if we let down the brushes *B B* and close a circuit upon them? There are now two paths open for the alternating current sent through *C*. One of them is via the armature windings, and against the counter electromotive force of the field to the other collecting ring, just as before the brushes *B B* were connected. The other is through the windings to a brush *B*, and through the external circuit to the other brush, thence through another bit of the armature winding to the opposite collecting ring.

Evidently the current will divide itself between these two paths, both being available. But the portion, which takes the path through *B B*, is passed through the commutator in the regular

---

*Abstract from the *Street Railway Review*, September, 1898.

way, and emerges as continuous current in the external circuit just as if it were generated in the armature itself. For the alternating impulses sent into the armature are timed with respect to the position of the windings just as if they were generated there and are kept in this relation by the fact that the armature is kept in synchronism by its action as a motor. The energy required merely to keep up this rotation is very small, and, as in other motors, the counter electromotive force automatically keeps the motor current down to the modest amount necessary to supply this energy. All the rest of the current which can be supplied to the machine up to the limit of endurance of the armature conductors may be taken from the commutator as continuous current. In fact, an armature used in this way will stand rather more current without overheating than could safely be generated in it. For the current which passes on to the line through the brushes *B B* is not compelled to traverse the whole of the armature windings, but only such parts of them as are between the brushes and the commutator segments to which the rings *C C* are connected. In fact, there will be a moment at which the current can pass directly from *C C* to *B B*, and on the average the path of the commuted current is much shorter than if the same armature were used to generate it. From what precedes it at once becomes a natural inference that any continuous current dynamo can be worked as a rotary converter if properly connected. This, within limits, is true, and the first rotary converters were formed by adding collecting rings to ordinary dynamos.

We have seen, however, that every dynamo is intrinsically fitted to generate current of a particular frequency at its regular speed, and unless supplied with alternating current of that frequency the speed would have to be changed in using it as a rotary converter. In point of fact most dynamos have too few poles to be thus converted unless at a much higher speed or lower frequency than is desirable.

POLYPHASE ROTARY CONVERTERS.

So far we have dealt only with the converter for single phase current, which is used only to a limited extent. Single phase synchronous motors are not self-starting, so there would be trouble in getting such a rotary converter up to speed, and, besides, there are excellent reasons for using in preference the polyphase systems for power transmission work. The polyphase rotary converters operate on precisely the same principles just explained and differ only in their connections. The machine shown in Figure 1 could be converted into a three-phase rotary converter by applying three collecting rings and connecting them to commutator segments as nearly as possible 120 degrees apart. It would operate in just the same way as before, but would be able to start itself like any other three-phase synchronous motor running light. Similarly we could make a quarter-phase converter by tapping the winding at four points 90 degrees apart and applying four collecting rings to be connected to the four wires of the quarter-phase system. Both these forms, the connections of which are shown, diagrammatically, in Figures 2 and 3, give shorter average paths for the commuted current than the single phase form, and hence on the whole give rather better outputs.

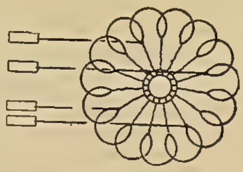


FIG. 2.—TWO-PHASE ROTARY.

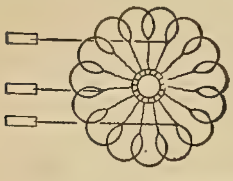


FIG. 3.—THREE-PHASE ROTARY

VOLTAGE RELATIONS.

Thus far we have said nothing about the question of voltage in rotary converters. The voltage applied can obviously be varied in almost any way, but it is equally obvious that if the commutator is designed for, say, 500 volts, it will give trouble as in an ordinary generator, if forced much above that point. In fact, the commutator of a rotary converter is designed like that of any other machine for a particular voltage, and since the current sent into the armature should be the same as that which could be generated in it, for any given continuous voltage the alternating pressure applied should be that which the machine would give if run as an alternating generator. This is considerably less than the continuous current voltage, since the mean effective voltage by which alternating current is rated is not the crest of the wave which, however, is the voltage, approximately, coinciding with that of the continuous current given by the same machine. Now in a single phase rotary converter the alternating current leads are taken out 180 degrees apart, and in a quarter-phase there are two pairs of wires separated by the same amount so that in these cases, if the machine give a sine wave, the effective alternating voltage would be $\frac{1}{\sqrt{2}}$ times the corresponding continuous voltage; *i. e.:* about seven-tenths as great. In the three-phase form the corresponding alternating voltage is still further reduced by the fact that while the continuous current brushes are 180 degrees apart, the alternating leads are only 120 degrees apart. The ratio in this case is $\frac{\sqrt{3}}{2\sqrt{2}}$ that is, about six-tenths.

Hence, if one wishes to derive from a rotary converter 500 volts for railway service, the applied alternating voltage will have to be about 300 to 500 volts. This, of course, means that in transmitting power for this purpose, step-down transformers must always be used. The exact ratio between the alternating and continuous pressures is subject to some slight variations due to the alternating wave shape and various minor causes, and one cannot in any way change either voltage without affecting the other. This is sometimes an inconvenience, for it makes the continuous current voltage subject to any inductive disturbances on the alternating side of the line.

Since the voltage at the commutator is not generated by the armature directly, it is not directly affected by the field strength as in ordinary dynamos, hence compound winding does not affect a rotary converter in the ordinary sense. Indirectly, however, it can be made to serve a useful purpose by reacting upon the alternating side of the line, and thus varying the applied voltage very materially. It is a well known fact that the voltage at the motor end of a line driving a synchronous alternating motor can be varied within wide limits by changing the field strength of the motor, and this holds true of the rotary converter, which, as we have seen, acts as a motor.

Another curious feature of the machine is the fact that the polarity of the continuous current derived from it depends on the way the alternating current is flowing when the brushes are put in circuit. If they catch a positive impulse the current is in one direction, if a negative impulse, in the other. As they are, however, so they stay, and it is not a difficult matter to get the polarity right.

GENERAL CHARACTERISTICS.

In their general behavior, rotary converters are strikingly like the best continuous current generators. They operate beautifully in parallel on either side or both sides, spark very little, show very little armature reaction, stand overloads well, and really leave little to be desired in point of efficient and smooth operation. Their efficiency is, in fact, rather higher than if they were used as generators, for the reasons already pointed out, and their use gives a thoroughly practical method of deriving continuous from alternating currents. Only in rare cases is their chief weakness—the complete interdependence of the two circuits—of any moment. Occasionally, when the transmission circuit is very long and must be kept clear of complicated line reactions, or when the frequency used is inconveniently high or low, it is best to fall back on the motor generator. Rotary converters can be built for any frequency, but a large machine for high frequency forces an extreme multipolar construction to keep down the peripheral speed, and this means a very complicated commutator. On the other hand, a very low frequency would compel a bipolar construction when a multipolar machine would be cheaper and better. Under ordinary conditions the rotary converter is at its best at from twenty to forty cycles per second.

When the motor generator is used it is a few per cent. less efficient than a rotary converter and somewhat more costly, but, counting in the cost and loss of efficiency in the transformers needed to supply low voltage to the latter, the difference is less than would be at first supposed.

ROTARIES IN RAILWAY SERVICE.

Having thus looked over the general properties of the rotary converter, we may pass to the conditions attending its economical use for railway purposes. In its relation to the working line it must be considered merely as a continuous current generator. So far as it is concerned with the trolley line proper, a sub-station with rotary converters is precisely the same thing as an independent generating station, with the same arrangements for feeding the trolley line and the same relation to the general conditions of operation. By employing such a sub-station one merely substitutes current delivered over high voltage feeders from a distant point for current generated on the spot. In general, the use of rotary transformers is for one of two purposes — to utilize water power situated at a point distant from the railway line, or to feed a long line from a single steam-driven station. These are two entirely distinct propositions so far as the economics of the matter is concerned.

The first involves the comparative cost of water power and steam power delivered at a given point, the second the relative cost of steam power generated in stations of different sizes and with different load factors. The margin for profit is generally greater in the former case than in the latter, and instances of the successful use of rotary converters are in the former correspondingly more numerous.

There are at present numerous examples of railways driven by transmitted water power through the agency of rotary converters. The first instance of this kind was the Portland, Ore., road, which for the past four or five years has been operated by a thirteen-mile transmission from the falls of the Willamette. Then there are the two great plants of this kind at Buffalo and at Minneapolis and a considerable list of smaller installations. It is not too much to say that all of these have been successful and economical, for they have substituted comparatively cheap water power for rather dear steam power. The question here is merely the general problem of electrical power transmission from waterfalls.

IN RE STEAM PLANTS.

When we come to the other case — the distribution of power from a central steam-driven generating station to sub-stations scattered over a city or along an extended railway line, the conditions are very different. Here there is no chance for wholesale saving in the cost of power, but there is the opportunity for substituting one large station for several of less capacity and dispensing with a very large amount of feeder copper. Ordinarily, when large amounts of power must be furnished to outlying districts, feeder copper is installed to meet the growing demand until finally the amount becomes very burdensome, and then a new station is built. As an alternative a sub-station with rotary converters and a high voltage feeding line may be installed. In the case of a long interurban line the feeder copper is a burden from the very start, and the question of separate stations versus transmission to sub-stations is at once pertinent. The advantages of this procedure may be very material. In the first place, all the power generation is done in a single large station, which can be located at the most advantageous point along the line, so that one gains the saving always found in working on a large scale. Second, by this concentration the central station gains in having a load factor somewhat better than any one of several separate stations could have, while the load factor of a rotary transformer station can never lead to any gross inefficiency.

All this is very nice, but there are a few other things to be remembered. The cost of the rotary converters, transformers, line and generator and station capacity to operate the sub-station system will generally be greater than the cost of separate stations — much greater if these stations are few in number and of fairly large capacity. Usually, too, the total labor account will be increased rather than diminished, since there will always have to be at least a small force at each sub-station and added force at the main station, besides the care of the transmission line, an item which it is by no means safe to neglect.

And finally, it must not be forgotten that for every kilowatt delivered from the terminals of the rotary converters, at least 1¼ kilowatts must be generated at the central station, and usually more than this. In other words, one cannot reasonably expect to get from the transmission system — line, transformers, and rotary converter — an all-day efficiency higher than about 80 per cent., and it will oftener be 75 per cent. than 80. If one were working under conditions of maximum economy, 80 per cent. could certainly be surpassed, but railway work does not furnish these conditions.

The cost of the transmission and depreciation thereon add still other charges against the system, and the upshot of the matter is that unless the central station can generate power fully thirty per cent. cheaper than it can be generated in several separate stations, distribution to rotary converter stations will not pay. Let us now proceed to investigate the chances of meeting this condition.

The first thing to be looked into is the variation of the cost of power with the size of the generating station and with the load factor. This is, of course, variable in each case, depending on the relative costs of fuel, labor, etc., but under particular assumptions as to these items for any special locality, the variation we are seeking can be readily deduced. The curves of Figure 4 give a typical case, and the relation between the different values indicated will not vary materially within the limits usually found in practice.

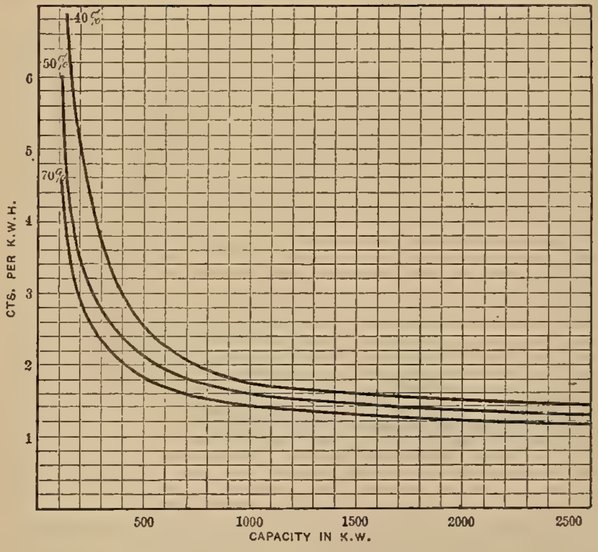


FIGURE 4.—DIAGRAM SHOWING COST IN CENTS OF KILOWATT-HOURS.

THE ECONOMIC FEATURES.

Figure 4 shows the approximate cost of power in cents per kilowatt hour for stations of 100 to 2500 kilowatts capacity, working at load factors of 40, 50 and 70 per cent. The latter figure is only reached in large city plants operating a great many cars. Fifty per cent. is a common load factor for well-handled systems of moderate size, and 40 per cent. is by no means rare. The curves are based on coal at three dollars per ton and steam and electric plants of average character, neither exceptionally good nor unusually bad. The absolute costs are of course only approximations, but are well borne out by the results reached in practice. They include interest and depreciation, two important items generally left out of the published costs of power, and hence appear high to the uninitiated.

Bearing in mind the fact that there is generally no difficulty in getting a good load factor in plants of 1000 kilowatts or more, let us look over these curves with relation to the use of rotary converter stations. From 1000 kilowatts upward the cost of power falls very slowly indeed. We have just seen that to justify the use of rotary converters a central generating plant must generate power much more cheaply than several independent stations, since to make up for losses in transmission and extra cost of plant, one must count on producing at least $1\frac{1}{3}$ kilowatts for each kilowatt delivered from the converter stations. It is therefore apparent that with sub-stations as large as 1000 kilowatts there is small chance for economy in using sub-stations, unless the total output is very great indeed. The central plant would have to run considerably over 10,000 kilowatts before it could pay to employ sub-stations of that size on street railway service. It is conceivable that if one were operating a long interurban road with heavy traffic and at high speed, such an arrangement might pay in virtue of improved load factor, but even in this case the long distances of transmission would tend to more than offset the gain. Data from actual plants tend to show, too, that above a few thousand kilowatts capacity, there is practically no material decrease in cost of power. There is strong reason to believe, therefore, that it can seldom or never pay to operate a large urban system from a single plant with rotary converter sub-stations. In fact, such a scheme of operation should be turned down on the score of putting too many eggs in one basket, if for no other reason. It may readily happen, however, that at some remote point of such a system a sub-station may be profitably utilized, employing, perhaps, rotary converters of a type that can be utilized later as generators when it becomes desirable in the growth of traffic to erect an independent station, or to link several stations together by a transmission system.

When the total output required must be divided into scattered units of only a few hundred kilowatts each, the advantages of transmission become more important. If, for example, one is operating a considerable interurban line requiring, say, a total capacity of 1000 kilowatts, and the question arises between two 500 kilowatts stations and a 1000 kilowatts station with a 500 kilowatts sub-station, considerable discrimination is required. At 70 per cent. load factor in a 1000 kilowatts station the cost per Figure 4 will be about 1.4 cent per kilowatt hour. In a 500 kilowatts plant at the same load factor the cost would be about 1.8 cent. This in itself is too small a margin to justify rotary converters. If, however, the 500 kilowatts plant cannot be assured of a load factor higher than 50 per cent., the cost will be, say, 2.15 cents, while the larger plant remains at 70 per cent., thus shifting the balance to the other side of the ledger. The question of economy, therefore, hinges under such conditions on the relative load factor of the whole system and of its parts. Few data are available on this particular item, since nearly all plants aggregating 1000 kilowatts, or even several times as much, are operated from a single station. In the few systems operated from several power stations the load factor does not vary greatly between station and station, but the stations are mostly so large that little variation would be expected. With an aggregate power as low as 1000 kilowatts, the use of sub-stations is evidently on debatable ground. On the other hand, with an aggregate power of 500 kilowatts such as might exist on an interurban line, the curves make it very evident that transmission to a sub-station would pay.

In general, one may safely say that unless a line requires for independent stations in the neighborhood of 500 kilowatts each, there is a strong probability that transmission from a single station will pay. With outputs above that point, sub-station work will very often be found to be uneconomical. The dividing line between the two cases appears to lie under ordinary conditions somewhere between 250 and 500 kilowatts for each station, where only two stations are concerned. It must not be supposed, however, that one can settle the case once and for all by installing a number of small sub-stations, for with extreme subdivision one comes at once into competition with boosting and other modifications of ordinary feeding systems.

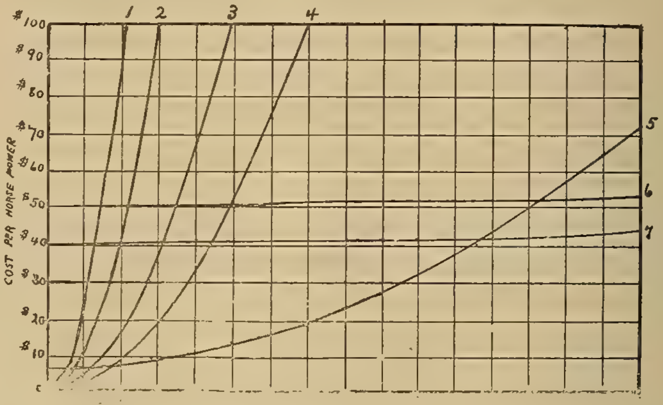
Under present conditions the rotary converter finds the most important use in the utilization of water power for railway purposes, and in this field its importance must not be lightly estimated. In some interurban work it is likely to find a legitimate and important use even when operated from a steam plant. In heavy city and surburban work its value is, to say the least, very problematical so far as general distribution is concerned, although it is not unlikely to prove a useful adjunct. Its chief weakness is in the fact that, like other moving machinery, it requires attention, and furthermore, it cannot be applied without a very material loss of energy. Skillfully used, however, it is a most valuable addition to the resources of modern engineering.

Electro-Economics

RELATIVE COSTS OF CONDUCTING SYSTEMS.[*]

BY CHARLES F. SCOTT.

ACCOMPANYING this are curves showing the general relation between the first costs of different systems for conducting power from the generator to the consumer. These curves are, of course, only approximate; the cost of conductors has been taken at about 15 cents a pound for copper, without reference to insulation; no allowance has been made for the middle wire of the three-wire system, and the cost of apparatus depends largely upon the size of the units used.



The cost for copper for 220-volt transmission and 10 per cent loss is seen to be $21 per horse-power for one mile and $85 for two miles. The cost is half as great when the loss is 20 per cent, but the distance for a given cost is increased only 40 per cent.

The cost for 2000-volt transmission includes a constant representing the lower transformers. The curve does not include the secondary conductors for the transformers. If the distance be short the cost is small. The lower curve for rotaries includes the cost of transformers, rotary and 10,000 volt circuit. The upper curve includes the direct current distribution circuits, assumed to have an average length of one-third of a mile, if the voltage is 220, and three-quarters of a mile if the voltage is 500—the loss being 10 per cent.

It is seen that the direct current transmission is cheaper to install than the 2000-volt alternating current with transformers, if the distance be less than about a quarter of a mile (the voltage being 220), or two-thirds of a mile (the voltage being 500). The cost of copper for 2000 volts becomes excessive when the distance exceeds a few miles; for greater distances a higher voltage should be used.

The curves representing the rotary sub-stations show a high first cost. This can be justified only by economics in operation. A comparison between these curves and the 2000-volt curve for the alternating current throughout shows the advantage of an alternating current distribution over that by direct current through sub-stations. Besides the reduction in first cost, the attendance at sub-stations is abolished, and the efficiency is increased.

"Let me congratulate you on your 'jim dandy' article on the San Gabriel transmission. You did yourself proud that time," writes a well known electro-technical literateur of New York City.

---

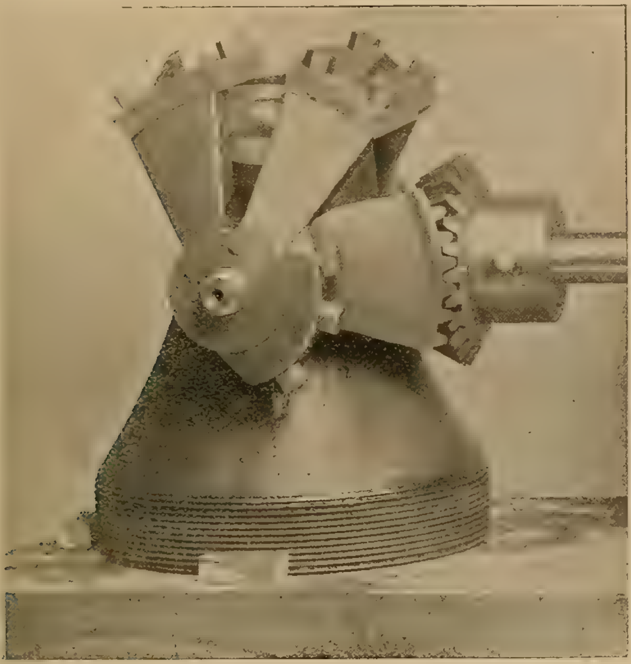
[*] From *The Engineering Magazine*, Volume XVI, page 267.

Hydraulics

CUT-OFF NOZZLES AT THE ASPEN POWER HOUSE.

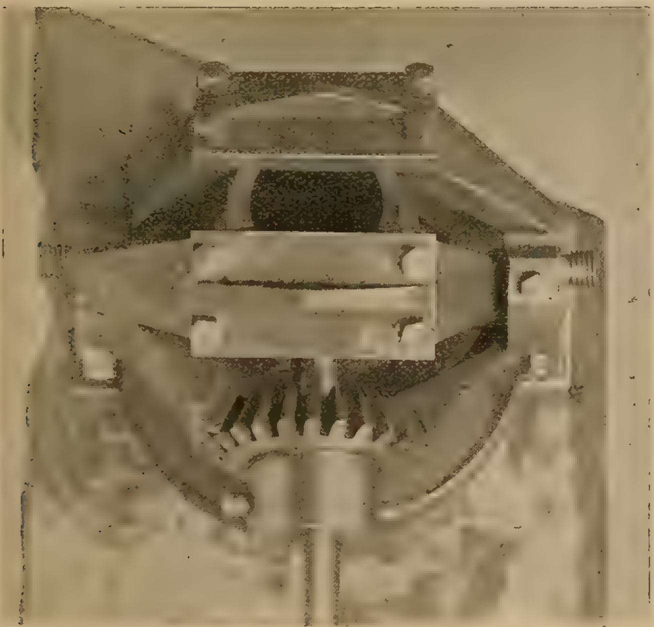
BY C. E. DOOLITTLE.

WATER for the pipe line of the Roaring Fork Electric Light and Power Company's plant, at Aspen, Colo., is taken from a reservoir at the lower end of the company's flume. The load consists largely of mine hoists and is, of course, exceedingly variable. As dependence must be placed in the supply of water in the reservoir to carry the run through many a cold winter night, it is necessary that the efficiency of the wheels be high at any load.



A DUPLEX CUT-OFF NOZZLE.—SIDE VIEW.

The Pelton wheels used are set in pairs and there are two nozzles for each wheel. The use of the valve or cut-off nozzle here illustrated, together with a device for operating the valves in succession, gives a much higher efficiency under variable load than is obtained in any other plant using reaction wheels of which the writer knows.



A DUPLEX CUT-OFF HOOD.—TOP VIEW.

The advantage of this form of valve over the hood valve which was used in the Aspen plant referred to some five years ago and which has since been used to a considerable extent, is that the direction is always tangent to the wheel.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

ENCLOSED ARC LAMPS OF NEW DESIGNS.

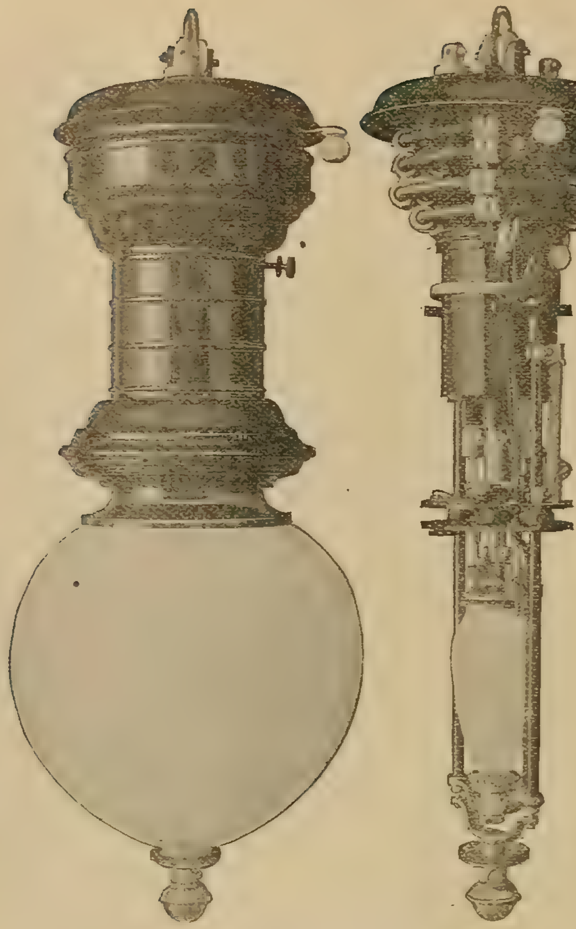
A PERFECTED form of carbon feed arc lamp for direct connection across 220-volt mains is being placed on the market by the General Electric Company. It operates with 120 volts at the arc, takes a normal current of 2.5 amperes, and, with one trimming, has a life of from 130 to 150 hours, requiring no attention during that time. The carbons are so proportioned that the upper carbon at the end of the run may be placed in the lower carbon holder for the next run. The light is of less volume and more violet in color than standard 110-volt lamps, but the advantages of a 220-volt lamp capable of independent operation, sometimes compensates for the diminution of light as compared with the General Electric 5-ampere power-circuit lamp for use two in series across 220-volt mains. A variable resistance at the top of the mechanism allows the use of the lamp on circuits of from 210 to 250 volts and disconnection from the circuit is effected by a quick break switch applied to each lamp. The 220-volt lamp is weatherproof and may be used without a hood, being especially suitable for lighting vestibules, doorways, window fronts, etc. It may be used with the closed outside globe as shown in the illustration or with the single globe and flared reflector. The casings are of several designs, the standard weatherproof casing being finished in black enamel.

220-VOLT LAMPS.

Following next in the line of enclosed arc lamps developed by the General Electric Company, a subtantial, simple, and efficient power-circuit lamp has been perfected for use two in series on 220-volt circuits, or five in series on 500-volt circuits. In outward appearance it resembles the alternating and direct-current carbon-fed enclosed arc lamps of the same company, and is manufactured in both single and double globe types. To conform to insurance regulations covering the use of arc lamps on high voltage circuits, a safe, positive and reliable cutout is incorporated in the lamp, together with an extra set of resistance coils. Should the carbons stick, or the lamp for any reason fail to operate, the cut out sends the current through these subsidiary resistance coils instead of through the carbons, without detriment to the lamp. The efficiency of this cut out has been demonstrated by cutting out lamps in circuit and allowing them to remain cut out for several consecutive hours, without resultant injury either to coils or lamp.

POWER-CIRCUIT LAMPS.

The mechanism is simple and made up of but few parts. The carbon is fed by a double cam clutch, smooth and positive in action. An adjustable resistance in the upper part of the lamp allows it to be employed two in series on circuits of 200 to 240 volts, or five in series on circuits of 500 to 600 volts. With one 12-inch positive, and one 5½-inch negative carbon, it burns after one trimming for from 130 to 150 hours, and after the run, the remainder of the positive carbon, as in the 220-volt lamp, can be used in the lower carbon for a second run of equal duration. The current required is five amperes. The lamp is furnished with the same globe lowering device that has been fitted to over 30,000 General Electric enclosed arc lamps, and which permits the globe to be lowered gently by merely turning a milled thumb screw at



POWER CIRCUIT ARC LAMP.

the side of the casing. The globe holder is locked automatically by a single upward movement of the globe holder. Power-circuit lamps are furnished in weatherproof black or brass casings, that shown in the illustration being the weatherproof casing.

MARINE ARC LAMP

MARINE LAMPS.

Adequate electric illumination of wharves, docks, warehouses, dry docks, shipyards, with their adjacent iron working shops, and the holds of vessels, while loading or discharging, demands a type of lamp somewhat different from that used for street or store lighting. It must be strong, compact and durable, or it will not withstand the hard usage which such service will naturally give it; it should give a large volume of clear, white light, which will not dazzle the eyes of the workmen nor throw heavy shadows in already obscure corners; it should require little attention, and be so simple that it can be attended by an average lamp trimmer; lastly, it should require trimming not daily, but only at long intervals.

The lamp which, perhaps, best meets these requirements is the marine enclosed arc lamp, also manufactured by the General Electric Company. It has been made the object of special design to adapt it to marine usage on shipboard or land. The mechanism is compact, simple and reliable, and is protected from injury or the effects of the weather by a stout metal casing. It is only necessary to renew the upper or long carbon once in 100 to 150 hours, the lower carbon, after the first run, being, as in the previous instances, the unburnt remainder of the upper carbon. With open arc lamps, it was necessary to renew the carbons every day. The outer globe shown as of clear glass in the illustration, is cylindrical in shape, of thick glass and protected from injury by a heavy wire guard. The globe can be lowered by a half turn of the thumb screw at the side, and when pushed back in position is automatically and securely locked. The lamp is only twenty-eight inches long. It can be carried from place to place if necessary, and hung by the metal ring at the top to any convenient hook, or may be permanently fixed in place like an ordinary arc lamp. The lamp can be used on a 110-volt circuit and can be adjusted for 4, 4.5, or 5 amperes, the latter being the standard.

Many of these marine lamps have been installed in locations such as those mentioned above, and have in every case given very satisfactory service.

MOVED TO MORE COMMODIOUS QUARTERS.

The Pacific Arc Lamp Company has moved from 23 Stevenson street to 149-155 Fremont street, San Francisco, where it has secured much more commodious quarters and greatly improved facilities for the manufacture of the Pacific Arc Lamp. The company has also secured large showrooms for exhibiting the "Northern" electric motors and dynamos, and the well known "Hardy" incandescent lamps, a large stock of each of which will be carried in San Francisco.

In addition the company has a large force of excellent workmen and are in position to do all kinds of repairing.

Mr. John Martin, of the Pacific Coast agency of the Stanley Electric Manufacturing Company, has been appointed agent of the Pittsburg Reduction Company, for the sale of aluminum for purposes of electrical construction in the west.

TABLE OF CONTENTS.

Illustrated articles are designated by an asterisk (*); Editorials by a dagger (†); Passing Comment by a double dagger (‡), and Industrial by a section mark (§).

Electro-Economics

*Relative Costs of Conducting Systems, by Charles F. Scott.......... 18

Gas

Acetylene—II, by Prof. Vivian B. Lewes, F. I. C., F. C. S............ 10
Graphite from Acetylene 14

Hydraulics

*Cut-Off Nozzles at the Aspen Power House, by C. E. Doolittle... ... 19

Illumination

§*Enclosed Arc Lamps of New Design........................... 19
†Gas vs. Electric Lighting.. 13

Personal

.... 11

Transmission

†"All That Glitters is Not Gold".. 12
*Rainfall in San Francisco from 1849 to 1898, by Marsden Manson, C. E., Ph. D.......................... 9
‡To Stanley Belongs the Credit.. 14
‡The Value of a Water Power.. 14
Water Powers in Southern California, by C. G. Baldwin.............. 5

Transportation

*Rotary Converters in Railway Work, by Louis Bell, Ph. D.......... 15

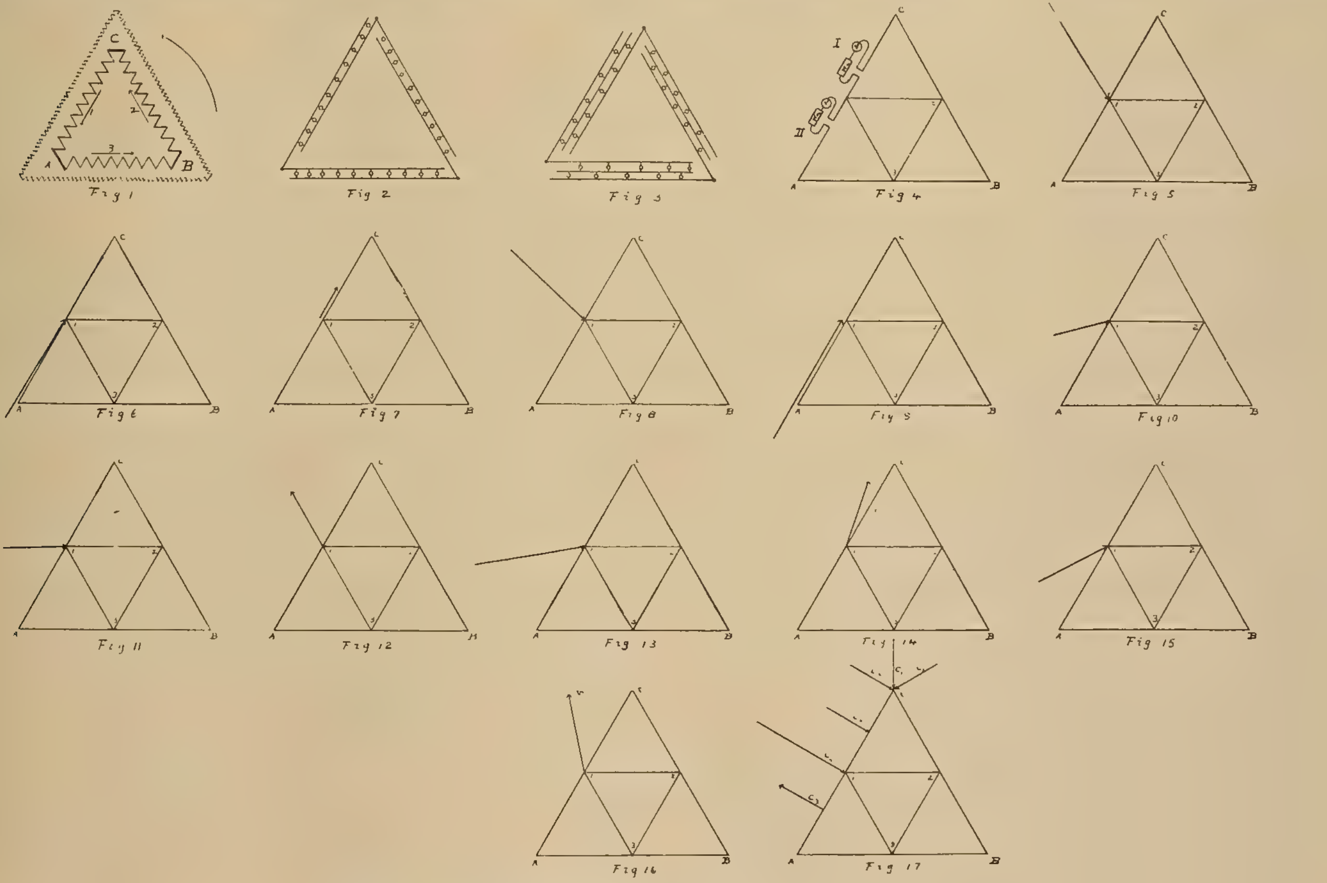
THE JOURNAL OF ELECTRICITY.

VOLUME VII. SAN FRANCISCO, FEBRUARY, 1899. NUMBER 2.

Three-Phase Transformer Manipulation.

BY A. J. BOWIE, JR.

NO other alternating current system at present in use offers as many different methods of obtaining and of using different voltages as the three-phase system. There are, of course, the "Y" and the delta connections commonly used, together with combinations of multipling the different coils of generators, motors, or transformers, as well as combinations of all these connections. It is also possible to obtain different three-phase voltages from the same set of transformers, and this article is the discussion of one method of so doing.



DIAGRAMS OF THREE-PHASE TRANSFORMER MANIPULATION.

Suppose the transformers are delta connected on the secondary, and that each secondary has a tap at its middle point. Then, obviously, there are four triangles which can be used, each of which will give half of the voltage of the main triangle, A, B, C. (See Figure 1.)

The triangle 1, 2, and 3, will, of course, give the most symmetrical arrangement and will divide the load more evenly than any of the others. If an evenly balanced load be connected to 1, 2, and 3, the result will be equivalent to the triangle 1, 2, C, supplying current for the load 1, 2. Likewise, A 1 and A 3 will supply 1 3 and B 2, and B 3 will supply 2 3 with current. Note that all cases considered apply to balanced loads alone.

Case 1 is with the load on 1, 2, 3 alone. If the load be non-inductive, then the current in C 1 will be nearly in phase with, and equal to, the current in 1 2; also the current in 1 A will be nearly equal to, and in phase with, current in 3 1. If the load be inductive, then the current in C 1 will lag behind the voltage 1 2 just as the current in 1 2 lags behind the voltage in 1 2; likewise with the currents in 1 A and 3 1.

Case 2 is with the load on 1, 2, 3 and also on A, B, C. In this case the currents in the transformers will be the resultants of the two currents supplying the different loads. This will, in general, produce very different currents in the two halves of the same transformer when the power factors of the two loads are different—a result which at first sight would appear improbable as the arrangement seems to be perfectly symmetrical. However, by examining the graphical diagrams, this is easily explained.

A series of tests was made as follows: Three 1½-kilowatt, General Electric, type "C" transformers, 1040 volts primary, 115 or 230 volts secondary, were delta connected, giving about 240 volts on the delta. These were tapped in the middle at 1, 2, 3. The loads used were as follows: Three sets of ten 32 candle-power lights, delta-connected for 120 volts, making 30 lights in all for 1, 2, 3. (Figure 2.)

Three sets of ten 32 candle-power lights, delta-connected for 240 volts, (two in series) making 30 lights in all for A, B, C, as in Figure 3.

The motor load, which was the same in both cases, consisted of a 220-volt, 5 horse-power induction motor driving a fan. The motor was under-loaded, but when it ran on 1, 2, 3, it was not able to run up to speed, as the voltage was too low.

In each case the actual resultant current came out somewhat less than that obtained by combining graphically the two components. But this was caused by the drop in voltage when under combined loads, as the transformers were much over-loaded in some cases. The direction of the current was found by using a wattmeter and taking the voltage off 1, 2, 2, 3, and 1, 3, respectively. Of course, this could have been found by the ordinary voltmeter, ammeter, and wattmeter method. An ammeter was placed in series with a wattmeter, and they were both placed in between C and 1, (which is designated by I), and after that between 1 and A, (designated by II in Figure 4).

The arrow indicates the phase and the amount of current flowing from C to 1, or from 1 to A in the transformer. The wattmeter and ammeter were standard instruments, but were not calibrated, as great precision was not aimed at; besides, the voltage varied somewhat while the readings were being taken, which would account for small discrepancies in the results.

The following is the list of diagrams:

CASE	LOAD	CURRENT	FIGURE
I	Motor on 1, 2, 3	19	5
II	Motor on 1, 2, 3	19	6
I and II	Lights on A, B, C	5.7	7
I	Motor on 1, 2, 3, and Lights on A, B, C	16.7	8
II	Motor on 1, 2, 3, and Lights on A, B, C	23	9
I and II	Motor on A, B, C	9.5	10
I	Lights on 1, 2, 3	10.2	11
II	Lights on 1, 2, 3	10.2	12
I	Motor on A, B, C, and Lights on 1, 2, 3	18	13
II	Motor on A, B, C, and Lights on 1, 2, 3	11.5	14
I	Lights on A, B, C, and Lights on 1, 2, 3	12.7	15
II	Lights on A, B, C, and Lights on 1, 2, 3	13.2	16

With a non-inductive load on the center triangle alone, only half the current capacity of the secondary is available. The full capacity of the primary, however, is available, as was shown by readings of the primary current not given here.

Tests were made with the lamp load alone on the different small triangles giving 120 volts. When the lights were on 1, 2, 3, the currents in all secondary coils were alike. However, when any of the other triangles were used, then in two coils of different transformers the currents were greater, and in the remaining four coils were less than in the first case.

For triangle 1, 2, 3, the current equals 10 amperes.

For triangles A 1 3, B 2 3, or C 1 2, the current (in two coils) equals 13 amperes, and the current in the remaining four coils equals 5½ amperes.

When the light load was put on A, B, C, in addition to the other load, the maximum current in any secondary when 1, 2, 3 was used was 13 amperes, whereas the maximum current when any one of the other small secondary triangles was used was 17 amperes.

Provided the load be balanced, the best small triangle to put it on is 1, 2, 3. Even at best, poor efficiency as regards the use of secondary copper is obtained, and the voltage drop for any load is very large. However, there might be many places where a connection of this sort might be useful; for instance, in a station where there was a 440-volt service and it was desired to run a small 220-volt motor on the same transformers. It would be inadvisable to run a system of any extent in this manner.

A system which might be used would be to run out six wires from the station, A, B, C, and 1, 2, 3, and to use the small triangles A, 1, 3, C, 1, 2, and B, 2, 3, for the lower pressure motor service (for small motors), balancing the motors on the three different triangles, and to use A, B, C for the larger motors. If a good balance were obtained this would give full transformer capacity, and would be practically equivalent to an Edison three-wire system, obtaining the advantages of transmitting at a high voltage. However, in general this system would probably be considered too complicated to use, due principally to the difficulty of obtaining anything like the proper balance.

Another case of interest is where three economy coils are connected delta and are equally loaded at the middle points, thus reducing the voltage 50 per cent. Tests were made with an arrangement of this sort, using as a load the lamps shown in Figure 2. The current C, 1, which enters the vertex of the triangle, splits up into two components, C, 2 and C, 5, which are very nearly at right angles to the voltage in the coils in which they flow, and are also nearly equal to the entering current C, 1. They flow along the two halves of each coil of the economy coil in the same phase, but in opposite directions and unite at the central point, giving the current C, 4 flowing into the load equal to the difference of the currents in each half of the economy coil ($C_4 = C_2 - C_3$, Figure 17). Note that in C, 3, the current is flowing from 1 to A, and not from A to 1.

KNOWS A GOOD THING.

"I cannot afford to be without THE JOURNAL OF ELECTRICITY; please renew my subscription," writes Mr. Frank Bourne, the well known mechanical and electrical engineer of New York City.

The Heretofore Unpublished Facts of the Pomona Case.

BY C. G. BALDWIN.

THE casual reference to the fact that William Stanley deserved the credit for the first commercial use of a 10,000-volt current in a long distance transmission plant, which appeared in my article in the January issue of the JOURNAL OF ELECTRICITY, seems to have excited some interest. As special attention has been called to this in an editorial note, I feel that it may be of further interest to know a bit of unwritten history.

The San Antonio Light and Power Company, of Pomona, based its plans upon the Frankfort experiment wholly, as at the time of its organization there was no commercial use of so high a potential in existence. It was necessary to convey the power thirty miles. The money to put in the plant was raised, and I went east to arrange the contract with the Westinghouse company, with which I had had correspondence.

I was greatly surprised to find that the then electrical engineer of the Westinghouse company was utterly unwilling to consider our plans. He maintained that the Frankfort Exposition transmission was a "laboratory experiment." The longest time it operated was five hours, while I must operate five hours or more for 365 days in each and every year.

"Our company," he said, "will not venture upon any such experiment."

I replied that the engineer who conducted the Frankfort work was a man of the highest reputation; that he said the insulation of the line gave him no trouble; that there did not appear a sufficient motive to make such a statement, if false; and that I believed commercial transmission at 10,000 volts was feasible and wanted to do it.

He still smiled at my credulity and firmly denied my request to consider it. When asked what he would recommend, he said "a 4000-volt generator and step-down transformers." I objected to the special make of a generator at our great distance, and especially to the cost of copper, which would be more than six times as great as I had figured upon. But I accomplished nothing. He said the Westinghouse company would not take the risk and pleasantly smiled me out of the office. I did not feel like smiling; I had apparently made a fool of myself, and a very public fool at that, having been at work for six months openly to organize the company. But I gave it up and dismissed the subject.

I then went immediately to Pittsfield, Mass., to attend a meeting of the American Board of Commissioners of Foreign Missions. Dr. R. S. Storrs, of Brooklyn, gave the address that evening. Its eloquence drove electricity from my mind, but as we left the hall the brilliantly lighted town suggested me to drop into a drug store to inquire whether there was an electrician of any prominence in town. The answer was "Yes; Stanley, of the Stanley Laboratory."

The next morning I went to Mr. Stanley's office, and threw down the plans and blue prints before him and asked him to look them over. He did so very hastily, and, closing them up, brought down his hand upon them, exclaiming, "Good! Good!"

"You don't mean to say that can be done, Mr. Stanley?"

"Done! Of course it can. Who says it can't be?"

"The Westinghouse company."

"Westinghouse company? Old fogies! Of course it can be done!"

He pushed a button and there came in from his laboratory some eight young men, among them Mr. Kelly, who has since won so prominent a place in the electrical engineering world. They sat down around the table and he read and commented upon the plans. He sent out for lunch and we were together until four o'clock that afternoon. Mr. Stanley went to the depot with me and on the way said: "I am not in the business of installing such plants. You go to the Thomson-Houston company and if they will not do it, why, I will. I can purchase their standard generators and we will make the transformers here. We will put up experimental lines, and we will guarantee results." I went to the Thomson-Houston company and they talked exactly as the Westinghouse company did. I had my talk with the secretary of the company, I think, but near the close of the conversation Mr. Coffin was present. When we finished, I arose to go, and laying my hand on the doorknob, said: "Well, gentlemen, I bid you good morning. I am glad there is one man in America who has the courage to undertake a new thing."

"What do you mean?"

"There is one man in America who will do this thing," I repeated.

"Who is it?" was asked, and both looked at me sharply.

"Stanley."

"Will Stanley do that?"

"Yes."

"Then we will. Come around in a week and we will give you figures." And they did.

Two weeks later I returned by Pittsburg and the Westinghouse company was ready to undertake the work. How the company had heard, I do not know, but it is certain that the company was ready, and it sent its agent, a Mr. Cook, to Pomona, and he got the contract, guaranteeing all results. This guarantee never cost the Westinghouse company a nickel, for, as I said in my paper referred to, the success was far beyond its highest hope.

The Westinghouse company is worthy of great praise and shares the glory; but it is clear that without Stanley the enterprise which led the world for high potential for two full years of commercial lighting by long distance electric transmission, would never have been undertaken. I undertook it from the standpoint of a layman, overestimating the value of the Frankfort experiment. Stanley was ready for it as an expert on transformers. He was splendid in his enthusiasm and he well deserves the credit given him.

The Fuel Oils of California.

STEAMING VALUE OF CALIFORNIA FUEL OILS.

BY GEO. H. LARKIN.

FUEL oil is found in various portions of the Pacific Coast, but its production has assumed proportions of commercial importance only in that portion of California from Fresno county southward. There are but four oil fields in California worthy of general consideration in a brief article of this character, and these four fields, named in the order of the fuel value of the oils they produce, are known as the Coalinga, Santa Paula, Los Angeles and Summerland grades of oil.

The chief characteristics of these oils are given in the following table, the calorific power being expressed in British thermal units per pound of oil, and the theoretical evaporation being shown in pounds of water evaporated from and at 212° F., per pound of oil consumed.

Variety	Gravity (Baume)	Weight per bbl	Estimated Heat Units	Theoretical Ev'por'tion	Water in Suspension
Coalinga	36°	300	23,000	23.8 lbs.	0
Los Angeles......	14°	340	19-20,000[*]	20 lbs.[†]	2% to 12%
Santa Paula.......	24°	320	21,000	21.7 lbs.	0
Summerland......	13°	342	19-20,000[*]	20 lbs.[†]	5% up[‡]

As is evident from the above table, Coalinga oil stands at the head of the list both as regards heat units and gravity. It is also perfectly clean, no foreign matter whatever being contained in the oil. The Santa Paula oil comes next as a clean product, although it contains more asphaltum, and is, consequently, not so rich in heat units as is the Coalinga oil, which is, so far as the writer is aware, higher in heat units than any other known fuel oil.

Both the Los Angeles and the Summerland oils vary a great deal as to gravity, according to the location of the wells. Some wells in the Los Angeles district have produced oil having a specific gravity as high as 19 degrees B., while the specific gravity of oil from other wells in the same district is not over 12 degrees B. The output of different wells varies between these two points, but when put together in a storage tank, the mixture has a specific gravity of from 14 to 15 degrees B. The same conditions hold good in the Summerland district, except that there the oil is of a more stringy, viscous nature, and appears to hold more water and sand in suspension than is the case with the Los Angeles oil. All the different oils mentioned seem to have about the same fuel value per barrel, providing that clean oil can be obtained, but in the case of the heavier oils it is impossible to separate the impurities without driving off the volatile portions of the oil.

The application of crude petroleum as fuel under steam boilers in competition with coal is entirely a question of comparative prices. There is such a great range in the quality of coal used on the Pacific Coast, that it is impossible to give any standard of comparison. Only a general statement may, therefore, be made, viz.: from two to four barrels of oil are equal to one ton of coal, according to the quality and grade of coal and the efficiency of the fireman. By using the proper kind of retort oil burner, it is possible at all times to get nearly theoretical conditions when using petroleum as fuel, which, together with its ease of handling and the perfection of its regulation, make crude petroleum the ideal fuel for steam users.

It is possible, however, to obtain a satisfactory estimate of the comparative costs of coal and oil fuels in all instances where the specific costs of fuel and evaporative efficiencies are known. Let us assume, for instance, that a certain steam plant is burning Welsh anthracite coal costing $8.00 per long ton, giving an evaporative duty of 11 pounds of water per pound of coal. Under these conditions, at what price per barrel can oil be burned to equal or greater advantage than the coal?

Obviously, the ton of coal evaporates 24,640 pounds of water, and as Coalinga oil producers stand ready to guarantee the evaporation of 16 pounds of water per pound of oil, it will require 1540 pounds of oil to perform the work done by 2240 pounds of Welsh anthracite coal in the plant. If oil weighs 300 pounds per barrel, the 1540 pounds of oil used amount to 5.1 barrels. Now, as 5.1 barrels of oil are required to do the work performed by $8.00 worth of coal, the equivalent price per barrel for the oil is $8.00÷5.1, or $1.56, which shows the price which can be paid for oil to compete on terms of equality with Welsh anthracite under the conditions assumed. If the oil can be bought at a less price, the difference represents the gain (or loss) that will be effected by the change.

A TEST OF CALIFORNIA FUEL OIL.

BY A. M. HUNT, M. E.

AN estimate of the value of California fuel oil for steaming purposes is available in a series of tests made during the recent Midwinter Exposition in San Francisco, where Puente oil was used exclusively. The oil was delivered on the grounds in tank cars. Two storage tanks, each holding about 6000 gallons, were placed in a cribbed box sunk below the surface of the ground at the rear of the boiler annex. This box was planked over and covered with a layer of sand six to eight inches thick, with a trap door to allow access to the locked door in the top of each tank. The oil was run from the cars directly into the tanks by gravity flow. Each tank was fitted with a vent pipe, through which passed the float rod indicating the level of the oil.

A steam pipe was carried into the top of each tank, to be used as a smother pipe in case of fire. The oil was drawn from the tanks by either of two pumps situated between the two sets of boilers, a separate suction pipe being run to each tank. These pumps discharged into the bottom of a small receiving tank made by a 5-foot length of 12-inch wrought iron pipe, capped at both ends. The oil was delivered from the bottom of this tank, either directly to the burner line, or through a Worthington meter into the burner line. The pumps were provided with pressure control valves actuated by pressure through a small pipe led from the top of the small tank, and were set to maintain a constant pressure on the burner line of between 11 and 12 pounds, no matter how many burners were on. An overflow pipe back to the big tanks was provided with a pipe safety valve, set a few pounds heavier than the governors. The small tank was also provided with a glass gage, and a safety valve placed on the top.

The operation of this combination was eminently satisfactory, and was entirely automatic, except that it was occasionally necessary to admit a little air to the small tank, or to bleed a little off, to maintain a constant level. The oil header ran the full length in front of the boilers in a cement-lined trough, with a drainage well at either end, and was covered with plates of iron. From the header, branches were carried up to supply the burners. Steam for the burners was supplied through a small header running along in front of the boilers, branches being taken out of the top to furnish dry steam. The operations of the oil-burning plant, and the use of the oil, was in every way satisfactory. At no time was there any difficulty with it, and the freedom from smoke, coal dust, and ashes makes oil pre-eminently a satisfactory fuel. The total quantity of oil consumed from the time of commencing its use until the close of the Exposition was 691,041 gallons.

---

[*] According to gravity and purity.

[†] With clean oil.

[‡] Water and sand in suspension.

The boilers in which tests were made were the ones used in daily operation of the machinery of the Exposition. They were of a well known fire tube type, rated at 375 h.p. each, and were 8 in in number, arranged in two groups of 4 each. The fuel was crude petroleum, furnished by the Union Oil Co., of California, and is produced in Ventura county. The Graves burner, manufactured in St. Louis, Mo., was used. No calorimeter tests of the oil were made, hence a report of its thermal units is not given. The oil came in through a center tube from a pipe fed by a receiver in which a constant pressure of 12 pounds was maintained. The steam passed in through an opening, caught the oil and sprayed it into the furnace. The amount of steam thus used approximated 7 per cent. of the boiler evaporation. There were grooves in the steam passage which gave the issuing steam a twisting motion, which was supposed to aid in breaking up the oil. There were 8 such burners to each boiler. The air for combustion was supplied through a double bottom architectural hollow tile bottom to the furnace. No grate bars, bridge wall, or combustion chambers were used, but a pile of loose, rubble-like fire brick was thrown in the back end of the furnace. The feed water supplied was taken from a Webster vacuum heater and passed through a Worthington hot water meter. The oil consumed was also measured by a Worthington hot water meter. Although meter tests are generally regarded with suspicion, the writer is confident that the results in this case are reliable. Before any tests were made, the oil and feed-water meter was thoroughly calibrated by weighing. A series of three calibration tests of the Worthington oil meter made on May 2, May 17 and June 5, 1894, showed the weight of oil per metered gallon to be 7.304 pounds, 7.466 pounds, and 7.364 pounds respectively. A similar series of four tests of the Worthington water meter, made on May 5, 7, 14 and 31, 1894, showed the weight of water per metered cubic foot to be 61.40 pounds, 62.78 pounds, 62.52 pounds, and 62.85 pounds respectively, all tests being with hot water and pumping against a boiler pressure of 125 pounds. The average of these tests gave 7.378 pounds of oil per metered gallon, and 62.39 pounds of hot water per metered cubic foot.

At first it was impossible to get concordant results, and sets of observations taken with the water at a high temperature, were particularly poor. A pressure gage was finally placed in the feed pipe on the boiler side of the meter, and the discharge valves passing the water into the barrels for weighing were set so as to maintain on the meter an average pressure equal to that in the boiler. The pump was run at the same speed as was found necessary to supply the water to the boilers tested on May 26. It was found after so doing that the results of the different sets of tests, as shown above, agreed very closely, *i. e.:* within two-tenths of a pound per cubic foot registered. This was as close as the limit of accuracy of the scales. The oil meter was provided with vents to enable any gas which might collect at the top of the meter chambers to be removed.

On May 26, 1894, a careful and systematic test was made of boilers Nos. 1, 2, and 3. In preparing for the test, the feed pump connections, except the ones leading to these boilers, were blanked, and No. 4 was filled to a mark on the gage and found to have gained nothing at the conclusion of the test. The blow-off connections were blanked and precautions taken that there should be absolutely no loss of water from the boilers. The furnaces were all set, and the full load had been on the boilers for about one-half hour before the tests began, and during the continuance of the same none of the burners were altered. The test commenced at 6:15 p. m., the height of water in the boilers having been noted, and terminated at 11:15 p. m., at which time the water was at the same level as at starting. The steam pressure was maintained as nearly constant as possible, and the water kept at a constant level. The thermometer used in taking the temperature of the feed was tested and found to be accurate. Readings were taken at fifteen-minute intervals. A great difference in the evaporation on two consecutive nights, on the same boilers, and under the same conditions, was due to a slight change in the adjustment of the burners and showed how important this matter is.

Other tests were subsequently made to get the average evaporation for a period of twenty-four hours on the entire boiler load, and were commenced at 7:00 a. m. The load from 7:00 a. m. to 10:00 p. m. consisted only of the condensation of the pipes and the slow running of one of the fire pumps. One burner was kept low in each of the two boilers, with only one boiler cut into the header. It was the usual practice to keep one boiler, in addition to those in use, warmed up in case of an emergency. At 10:00 a. m. practically the full load was thrown on one boiler. At 12:30 p. m. the second boiler was cut into the header with about one-quarter load. At 1:30 it had about one-half its load, and the third boiler commenced warming up. At 3:35 commenced to warm up the other two boilers. At 6:20 cut in two more boilers, making four in operation. At 6:40 cut in the fifth boiler. The load until 10:00 p. m. continued until fairly constant, four boilers fully loaded, and one with partial load, at which time the boiler with partial load was cut out and burners reduced in others. At 10:30 cut out two more boilers. At 11:00, load was reduced to about one-sixth load of one boiler, and another kept warm. From 4:45 a. m. to 7:00 a. m. the only load was the condensation of the pipes and the movement of one fire pump.

The evaporation obtained was 12,986 pounds of steam per 1,109 pounds of oil, from and at 212°, or practically 13 to 1. This result was excellent when the amount of oil consumed in warming up and in keeping one boiler in constant readiness to be cut in, is considered.

DEVELOPMENT OF CALIFORNIA OILS.*

AS far back as 1857 an oil well was put down on North Spring street, near Franklin, in the city of Los Angeles, but after going down 800 feet, work on it was suspended. About the same time a well was sunk at Main and Requena streets and drilled to a depth of 900 feet, when it was abandoned. The Union Oil Company also expended at different times and in different places a considerable sum of money in its efforts to find oil in paying quantities.

It was not, however, until August, 1893, that oil was found in paying quantities. It was in a well put down near the junction of West State street and Lakeshore avenue. At a depth of 150 feet the well showed a yield of two barrels a day, and as it was selling for $2.00 a barrel, further work was vigorously prosecuted. Since that date the increase in production has been so great that the total production of the Los Angeles field alone up to the end of the year just closed, exceeds 5,100,000 barrels. That is the fact which has made the discovery of petroleum in Los Angeles one of the most important incidents in the history of the city.

Starting from August, 1893, the date when the oil industry of Los Angeles began its history, the production of each year has been as follows: In 1893, 100,000 barrels; 1894, 400,000 barrels; 1895, 900,000; 1896, 1,200,000; 1897, 1,400,000; 1898, 1,100,000; total, 5,100,000 barrels. During that period prices have ranged from 30 cents a barrel to $1.65 a barrel in the field. The minimum price was reached in May, 1895, and the maximum price in March, 1897. At the present time the average price per barrel is $1.00.

During the entire period of production, that is to say from August, 1893, to December 31, 1898, the average price of oil at the wells has been about 65 cents a barrel. Figuring on that basis, the total selling value of the oil produced in the Los Angeles field to the present time amounts to $3,315,000. This does not include the cost of drilling, erection of derricks, wages, and the other expenses incurred in the maintenance and pumping of the wells.

There have been, as nearly as can be determined, 1020 wells drilled in the Los Angeles field, of which 625 are now being pumped. The average cost of a well is $2300, making the total amount expended for the 1020 wells put down, $2,346,000. The average monthly cost for the maintenance of a well is $50, so that the wells now being pumped necesitates the disbursement of about $30,000 a month for wages and incidentals. The average

---

*Abstract from the Midwinter Number of the *Los Angeles Times*.

Los Angeles oil is about fourteen and a half gravity. The total amount collected by the city for licenses to oil men from April 1, 1897, date when the tax was imposed, to December 31, 1898, was $8585.

It is estimated that the petroleum production of southern California during the year just ended was in the neighborhood of 2,050,000 barrels, divided between Santa Barbara and Ventura counties, the Fullerton field in Orange county, and the Whittier, Puente, and Los Angeles fields in Los Angeles county. The production in the Fullerton fields shows a large increase over that of 1897. Whittier also shows an increase. For Ventura and Santa Barbara counties the combined production is estimated at 740,000 barrels for 1898, as against 660,000 barrels for 1897. The Los Angeles local field is the only one that will show a decrease, the figures for 1898 being placed at 1,100,000 barrels as against 1,400,000 barrels of production in 1897.

During the first half of the year 1898 the average production of the Los Angeles field was 4000 barrels a day. During the last half of that year the average production has been about 2800 barrels a day. At the present time the production is about 2300 barrels a day. Taking 2800 barrels as the daily average for the field for the last six months, the decrease, as compared with the first six months of 1898, would be 1200 barrels a day, or 216,000 barrels for the half year. It is not believed that the production during the present year (1899) will fall below the present production of 2300 barrels a day. Rather may it be expected that the year will show a slight increase on that average, a search for new oil deposits being prompted by the better prices now obtained. It is also quite possible that the cost of production will show a slight reduction, if, as is hoped, some of the wells now being deepened show an increased flow at greater depth.

Stocks which have just been taken show that at the close of 1898 there was above ground in the Los Angeles field 240,000 barrels of oil, of which 70,000 barrels were in tanks in the field, and 170,000 barrels in the various storage tanks in the city. At the present rate of consumption, this is equivalent to about four months' supply.

A peculiarity worthy of note in respect to the Los Angeles oil field is the comparatively small proportion of dry wells, and of wells that did not give a paying yield. During 1895, when prices broke to 30 cents a barrel, a number of the smaller wells were shut down, simply because it did not pay to pump them with oil at 30 cents a barrel. But under normal conditions such wells would not have been classed as non-payers, and would not have been shut down. Some of these wells are now being reopened and are being sunk to a greater depth with good results.

The Puente oil fields are in Los Angeles county, and about five miles distant from Puente Station, on the Southern Pacific Railway. Prof. W. L. Watts in his report on them to the California State Mining Bureau, says "the hills in which the Puente oil wells are situated, appear to be an east extension of a line of elevation which can be traced in a southeasterly direction from the city of Los Angeles. These hills, as seen at the Puente oil wells, are formed by a series of closely compressed folds in the rocky formation, which have an east and west trend. At the base of these hills soft sandstones and conglomerates are found, and in some places a white, chalk-like, diatomaceous rock, similar to that seen at Los Angeles, alternates with reddish-brown sandy strata, forming parti-colored banks, in which the strata vary from a few inches to less than an inch in thickness." About thirty wells in all have been drilled, only a few of which were non-productive. Generally speaking, the Puente wells have very remunerative, and there are reasons to believe that they can be made more largely productive than they have, when the necessity for an increased production arises. The production of these wells during last year was over 100,000 barrels.

The wells at Fullerton, in Orange county, are showing a considerable increase in yield. The Santa Fé Railway Company has sunk eleven wells in that district and is now sinking its twelfth. Besides the properties of the Santa Fé, some others have been lately located and companies formed to develop the oil deposits believed to exist in the Fullerton region. Among these is the Columbia company, which has sent in a quantity of machinery and will get to drilling without delay.

From January 1 to May 1, 1898, the average production of the Fullerton wells was 150 barrels a day. Since May 1 the production has increased, and the reports of the Santa Fé company show that from that date to the end of the year, the average production was 225 barrels a day. The total Fullerton production for the year 1898 was about 70,000 barrels.

Next to Los Angeles county, Ventura is the largest oil producing county in California. In 1897 its production was about 500,000 barrels. For 1898 its production is estimated at 560,000 barrels, with a continuing increase. The Union Oil Company of Santa Paula handles the bulk of the oil produced in Ventura county, the greater portion of which is shipped to Olean, near San Francisco, where it is refined. The company has an elaborate pipe line system, connecting Ventura with its different oil fields in the county, and the oil is either carried by gravity or pumped to the wharf at Ventura, where it is loaded on a tank steamer. The pipe line system is over 100 miles in length. The deepest wells in the state are those sunk by the Union Oil Company in Ventura county.

In Santa Barbara county the principal oil wells are at or near Summerland. The Summerland oil is a heavy oil more closely resembling the Los Angeles oil than that found in any other part of southern California. Within the last three months the production of the Summerland field has been greatly increased through the discovery of what are known as the "beach" wells. These wells are situated on the ocean beach below high tide mark, and they are the only beach wells known. They have proven themselves good producers and new wells are steadily going down. A peculiarity of these Summerland wells is the comparatively shallow depth at which natural gas is encountered, and in such abundant quantities as to furnish enough for partial lighting purposes. Only a few weeks ago in a well that was being drilled the pressure of gas was so great as to throw out all the boring tools. An effort will probably be made to discover to what extent this natural gas can be utilized.

It can be said that the petroleum industry of Los Angeles, and, in fact, of all southern California, is in a much better condition at the beginning of 1899 than it was a year ago, or at any previous time in its history.

Following is a report made by Prof. W. L. Watts, of the California State Mining Bureau, who has been making a systematic investigation of the petroleum deposits of southern California:

"A review of the petroleum industry in southern California shows continued activity in the Los Angeles oil field and the oil territories of the Puente, Santa Fé Railway Company, the Central Oil Company, in the Puente hills, the oil field of the Pacific Coast Oil Company near Newhall, and the oil fields of Ventura and Santa Barbara counties. The price of oil has also been more satisfactory than it was during 1896-97, and it is probable that the total output for 1898 will greatly exceed any previous annual output of petroleum in California. During 1898 there has been a marked tendency to exploit new territory. In Los Angeles county three new companies have commenced operations in the Puente hills, and new territory is being developed at three or four places near Newhall. At Los Angeles drilling was actively prosecuted during the first half of 1898 in the eastern extension of our local oil field, but recently little has been done toward extending its limits. There has been some exploitation in the outlying portions of Los Angeles, but the only marked success has been on the Maltman tract, where several comparatively shallow wells have been drilled which are remunerative. The only really new group of productive wells reported as being drilled in Los Angeles county during 1898 are those of the Home Oil Company near Whittier.

"In Ventura county drilling has been active on both sides of the Santa Clara river. This has resulted in many new and productive wells being added to those already in operation. There have been reported from Ventura county several new wells drilled during 1898. On the south side of the valley of the Santa Clara river numerous new and productive wells have been drilled by the Union Oil Company; also several by the Eureka Oil Company. On the north side of the Santa Clara river the Modello Oil Company has sunk six productive wells near Piru, and there have been sundry developments by the Eureka and other companies in Hopper canyon. In the Sespe district several new and productive wells are reported to have been sunk. Garbutt & Co. have developed a new and productive territory; also on the Temescal ranch, near Piru, one productive well has been sunk by D. C. Cook, who is about to commence active operations on that ranch.

"In Santa Barbara county the principal development has been at or near Summerland, where a line of derricks extends not only along the seashore, but out into the ocean. The Arctic Oil Company is also drilling in the edge of the Santa Ynez mountains, near the Casitas creek, and some development has been made by the Occidental Oil Company, about five miles northeast of Summerland.

"In central California the most important event in the petroleum industry during 1898 has been the development of the Coalinga oil fields, in Fresno county, which is proving a valuable addition to our petroleum supply. Concerning the Moody Gulch oil field, in Santa Clara county, we have no data for 1898.

"The geological investigations concerning the occurrence of petroleum in California which have been made by me for the California State Mining Bureau during 1898, have been made along a line extending from the Santa Ana mountains, through the Puente hills, to Los Angeles along a line extending about ten miles inland from the seashore between San Diego county and Newport, in Orange county; also throughout certain territory in Ventura county, lying between Piru creek and the Sespe oil mining district. The latter was described in the eleventh Bulletin of the California State Mining Bureau. It is interesting to note how the probable dimensions and directions assigned to the Los Angeles and the Summerland oil fields in the bulletin referred to have been borne out by recent developments."

Illumination

NERNST'S ELECTRIC LAMP.*

BY JAMES SWINBURNE.

CONSIDERING the enormous importance of the incandescent lamp its improvement has received extraordinarily little attention. It limits us as regards pressure, it used to hamper us by its cost, it limits as as to variation of pressure, and it limits us very seriously by its inefficiency. Yet, in spite of these, the carbon incandescent lamp has made practically no advance in fifteen years. Of course mere detail improvement in manufacture has taken place, and this has led to better quality and greater uniformity, hence cheapness; but there has been no radical improvement. The jump to 200 volts from 100, or from 50 to 100, did not depend on any sort of radical improvement in the incandescent lamp; it was merely the result of detail improvements making it possible to produce long thin filaments. Other things being equal, it is easy to see that long thin filaments must be weaker. If the carbon has the same specific resistance the relation between pressure and length is $E=L^{\frac{3}{2}}$, and $E=D^{-\frac{3}{2}}$. If the filaments are flashed the proportions will be still more extreme. The question of high-pressure incandescent lamps is thus: How far can we make the filaments longer and thinner and flimsier without exasperating our consumers? Unfortunately the consumer is rapidly getting saddened as it is. The 100-volt 8 candle-power lamp does not please him much, and the 200-volt 8 candle-power lamp has in no way delighted him; if the lamp is made with two 100-volt filaments in series it combines the disadvantages of both without the advantages of the smaller candle-power of either. But it adds some further disadvantages peculiar to the higher pressure which I have not so far touched upon—and that is, the higher the pressure the more troubles there are through the silent discharge, or whatever it is called. I need only refer to the well-known experiment in which third terminal is sealed into the lamp. A galvanometer then shows a current going across country inside the lamp. This is, no doubt, intimately connected with the life, or rather with the death of the lamp.

I have dealt with the question of high-pressure incandescent lamps at some length because the subject is really of vital importance, and is too much neglected. Our technical colleges, and our technical press, and our technical societies pay the greatest attention to questions of a per cent. or two in the efficiences of dynamos and transformers, and give a good deal of attention to engines and boilers. That is because there is plenty of room for calculations in connection with these subjects, but the incandescent lamp, which at present holds the whole career of the lighting industry in the little curl of flimsy red-hot carbon that can hardly support its own weight, receives no attention at all. How much does the average electrical engineer know about incandescent lamps? The only subject that is treated in the same way is the cable. About half the money in town lighting goes in the cable—a mere fraction in the dynamos and transformers themselves—so the average electrical engineer knows nothing about cables.

So far I have only discussed the incandescent lamp; the arc lamp has also to be considered. I will not say much about the arc lamp just now, but will add a little more when the Nernst lamp is compared with it. The ordinary arc is limited in pressure to about fifty volts, including the series resistances necessary for regulating. The enclosed arc is a new development, which is more satisfactory as regards pressure and as regards consumption of carbon.

The lamp I describe to-night is the invention of Prof. Walther Nernst of the University of Gottingen. Though he is a young man, Prof. Nernst's name is already known to all modern chemists as a leading authority and original thinker in the field of physical chemistry. It is unusual for a man who has climbed to the top of one tree to jump to the top of another.

Nernst's, like most great inventions, is exceedingly simple as soon as it is understood. The efficiency of an incandescent body, as far as radiation goes, depends on the temperature of the filaments. The most refractory materials so far used in lighting are zirconia, which has been used to replace lime in the limelight, and the oxides or so-called rare earths, in the Welsbach mantles. I am aware, of course, that many people suppose that the Welsbach mantle is not very hot, treating it as if it were at a temperature, for instance, below the melting point of platinum. The light emitted is supposed to be due to some special power of selective emission due to the the oxides employed. I have had a good deal to do with incandescent gas mantles, and I find no reason to suppose that there is any magic effect of this sort going on. The part of the flame where the mantles hang fuses platinum wire easily, and very few materials can stand the temperature without fusing or volatilizing. Lime and many other oxides volatilize slowly from the mantles. I do not mean that the mantles are above the boiling point of lime; I have some idea of its melting point, as I have made a few pounds of melted lime and ran it out on the floor to look at it. The Welsbach mantles, which are now chiefly thoria, are at a temperature near their softening point, and in the making are raised to a temperature at which they begin to soften.

Nernst takes highly refractory oxides as his material. It does not seem promising, because such oxides are notoriously good insulators. But such insulators are electrolytes when hot. Nernst, therefore, heats the rods to make them conduct, and then heats them electrically, preserving a temperature which is within the limits that the material can bear without softening. This means that he can take the most refractory bodies supplied by the whole range of chemical research, and can heat them to a temperature short of their softening point, and can thus get an efficiency unknown to workers on the incandescent lamp. Such efficiency also means whiteness of light so long as the efficiency is not too high. Thus the crater of the arc, being at a temperature of boiling carbon, gives a light that is unpleasantly blue.

---

*Abstract of a paper read before the Society of Arts, London.

The material is worked up into little white rods. Each rod is mounted on two platinum wires, a little paste made of refractory oxides being applied to the joints. The little rod with its two wires is then mounted on a holder which fits ordinary electric light fittings. As the rods fall in resistance as the temperature increases, after the manner of electrolytes, an increase of current produces a decrease of resistance. This tends to give some instability in running in parallel on supply circuits. This instability is corrected, as in an arc lamp, which has analogous properties, due to a different cause, by a series resistance. The Nernst rod has therefore a resistance in series. This is made up of exceedingly fine wire, and for ordinary circuits amounts to ten or twelve per cent. of the whole resistance of the lamp. The consumption, including the resistance, is 1.5 watts per candle power for large lamps and 1.6 for small lights or low pressures. In small or low-pressure lamps the loss of heat at the ends is larger in proportion.

Such a lamp as I have described will not light up of itself, for the rod is an insulator when cold. The simplest way to start it is to warm it up with a match, or better, with a small spirit lamp. Such a lamp as this is not only very cheap as regards first cost but very economical in running. The life of rods, running at an efficiency of two-thirds of a candle per watt, including the resistance, is already more than 500 hours in good specimens. If the Nernst lamp advances as much in the first few years of its existence as the carbon lamp did between 1880 and 1882, it will soon be made so well that the rods last a lifetime. When the rod is worn out a new rod with its wire mounts is all that is replaced. The whole lamp is not thrown away at all. The method of lighting I have described, though it may be used in many cases, such as large public rooms, is really a savage mode of ignition, fit only for dealing with uncivilized commodities.

The small lamps and the lamps of medium size are in practice started by a heating resistance. This is arranged close to the rod and in shunt to it. As soon as the rod is hot enough to conduct, its current works a tiny cut-out in the resistance circuit. In large lamps the heating system is a little more elaborate, as the resistance arrangement is arranged as a sort of hood which covers the rod. As soon as the rod conducts, not only is the resistance circuit broken, but the electro-magnet lifts the little hood clean off the rod. In all these forms, the rod and its mounting are replaceable without interfering with the rest of the lamp.

We now have to consider the part that the Nernst lamp is probably going to play in the near future.

Compared with the small incandescent lamps, as you deal with a material of much higher specific resistance, it is easy to give both small lights and high pressures. The question of lighting is exceedingly important, though it appears trifling at first sight. People are so accustomed to lamps being turned on from the door without any further trouble that they will generally object to have to light them with matches or spirit lamps, but there are many cases in which it will be quite satisfactory to have one lamp with an automatic lighter to show you the way into the room, the rest being lighted with matches or a spirit lamp as needed. There will be, however, a considerable opening for the cheap, small-power, high-efficiency lamp, and the disadvantage as to lighting is small in such cases as cafes, restaurants, churches, hotels, railway stations, and, in short, in most public rooms.

Coming now to the next size—that is to say, lamps of 20 candle-power to 200 candle-power, and even small lamps in which it is worth while to have automatic ignition—the first cost of such lamps will be higher than the first cost of incandescents, but as the rod itself has alone to be replaced, that is a matter of very slight importance. This size of Nernst lamp, has, further, every chance of completely ousting the carbon incandescent on the score of cheapness, as to renewals, higher efficiency, better colored light, and, perhaps, more especially, high pressures. Once the Nernst lamp becomes so general that systems of distribution are laid out to suit it, instead of to suit the carbon lamp, the carbon lamp is practically "out of the running." It must be remembered that the Nernst can compete with the carbon filament at any pressure that suits the filament, but the Nernst lamp can easily go right out of the depth of the filament and have the higher pressures to itself. It must be remembered that at present the cost of cables in a system of distribution is an exceedingly large item.

Turn now to the large lamps, they compete with the arc lamp in efficiency. Of course the efficiency of the arc lamp is not a definite quantity. The candle-power is generally determined by multiplying the current by two and adding zeros at discretion. All I can say is, that however many zeros the good nature of the maker may supply, a Nernst lamp taking the same power gives a better light. When carefully arranged on the photometer, the arc may be better in given directions, but a lot of light given in directions that you do not want is not the same as the same light distributed with a uniform spherical emission. The arc lamps shown here will give the audience a good idea of the relative values. The Nernst gives a pleasanter, and of course, a perfectly steady light. Coming to costs, the Nernst will be very much cheaper in first cost, but enormously cheaper in maintenance. It also goes quite away from the arc as to pressures. There is no trouble, for instance, in making large lamps to work in parallel at 500 volts and by using double rods at 1000 volts. This puts an entirely new development of electric lighting in the hands of the engineer.

There is one point I have said little about yet. The incandescent lamp which is still with us gives trouble not only because of the low pressure it needs, but also because it demands that the pressure shall be kept uniform. It seems quite possible that the Nernst lamp may be made to stand a much greater variation of pressure than the filament. If this proves true it means an enormous difference in the designing of distribution mains. I do not like to say much about this yet as the invention is too young and too little time has been available to make much certain progress in that direction. Results are promising but it is best not to be too sanguine.

It is difficult to discuss an invention like this without being carried away with enthusiasm. I feel, however, that I have but feebly shown forth the probable future of what seems to me the greatest invention in electric lighting that we have seen for many years. Still I am sure I have not been too sanguine.

Transmission

REGULATION BY LEADING AND LAGGING CURRENTS.

THE unusually elaborate application of the various principles of alternate current working as applied to the regulation of the voltage of the Mechanicville-Schenectady transmission, forms an interesting feature that was not incorporated in the description of that installation as given in THE JOURNAL OF ELECTRICITY for September. This plant, as will be remembered, delivers power in two divisions to the General Electric Company, one for the testing department and the other for the running of the various motors driving the machinery of the shops. The former is supplied by a motor-generator set, consisting of a synchronous alternating current motor wound for high tension supply, coupled to a 500-volt multipolar railway type generator. The speed of this unit is obviously dependent only upon and equal to the speed in alternations per minute of the generators at Mechanicville and the voltage of the direct current end is thus obviously not affected by any changes of the voltage of the power delivered by the transmission line. The shop motors, however, are supplied through step-down stationary and rotary transformers, and as the voltage of the direct current end of this sort of a transforming system is dependent on the alternating current voltage delivered, special means are necessary for properly adjusting the latter to obtain proper pressure on the distribution lines. The means adopted in this case are the use of leading and lagging currents by which the ohmic line drop can be inductively diminished or increased — a means previously used, notably in the St. Anthony Falls line — combined with an ingenious modification of a plan claimed in a patent issued to E. W. Rice, Jr., December 14, 1897.*

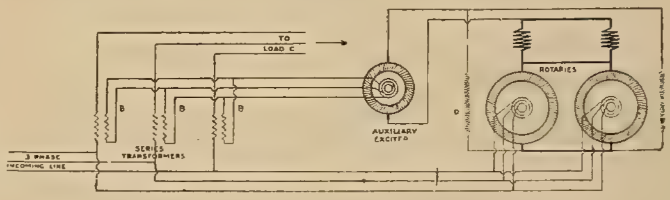
The system is practically compounded for constant potential at the direct current terminals of the rotaries, or it may be over-compounded at that point. The compounding is effected not internally in any machine, but strangely enough in the transmission line itself. The latter consists of three No. 000 wires all mounted on one cross arm, which gives double the self-induction between the two outside wires as between either of them and the wire in the middle, but this effect is neutralized by the transpositions of the lines, another purpose of which is the reduction of inductive disturbances in neighboring telephone circuits. The rotaries at the receiving end of the system are compound wound with quite a heavy series winding, the ampere turns of the two field windings being so proportioned that on no load the excitation of the shunt winding is sufficient to generate at synchronous speed a back electromotive force sufficient to choke back the impressed alternating current waves.

The result is that wattless currents lagging behind the impressed electromotive force enter the rotary armature and automatically increase the field excitation to a proper value. These lagging currents react upon the self-induction of the line, causing a drop considerably greater than that due to its resistance alone, and — the direct current voltage being practically proportional to the impressed alternating voltage at the rotary rings — the reduction of the latter by means of the increased line drop prevents too great a pressure being delivered from the direct current end on no load.

As the load rises, however, the action of the series fields of the rotaries begins to assert itself. As the direct current excitation of the fields increases the wattless currents in the armature necessary to maintain the field excitation fall off until at a point about three-quarter load the power factor of the incoming current approaches unity and the voltage drop on the line is equal only to the amperes multiplied by the line resistance. On further increasing the load the exciting action of the field windings of the rotaries becomes sufficient to generate a back electromotive force at synchronous speed greater than that delivered, and, as the rotaries cannot change their speed, but must remain in synchronism with the generators at the other end of the line, the alternating currents, so to speak, automatically cut down the field excitation by a flow of wattless currents leading to the impressed electromotive force. The action of this on the line inductance is the reverse of that of the lagging currents described above. In other words, the line drop is diminished and, in case the leading current and line inductance are of sufficient magnitude, the voltage-boosting effect in the line may even be greater than the ohmic or resistance drop, in which case the voltage at the receiving end is greater than that at the generating end. The direct current pressure being proportional to the alternating current pressure delivered, it is in turn compounded or even over-compounded if necessary. The direct current pressure delivered by the rotaries is thus increased just as though they were engine-driven generators, by the use of a compound winding, but the effect is not immediately due to action of an increased field flux on the armature conductors, but is due to a boosting or depressing action of the inductances of the transmission circuit on the alternating currents therein.

In the case of the Mechanicville-Schenectady system, there is, of course, in addition to the self-induction of the line, the self-induction of the rotaries and stationary transformers and the generator armatures, at least for the present. If at any later time other transmission lines are run from Mechanicville to other cities, it will become necessary to excite the generators for constant potential at the switchboard in order to prevent the various lines interfering with each other. In this case the self-induction of the generators cannot be depended upon, but at present the generator fields can be left at constant excitation and the voltage at Schenectady controlled entirely automatically by the compound fields of the rotaries, the self-induction of the generators materially aiding the inductive compounding.

This arrangement alone would be sufficient to obtain proper voltage regulation but for the interference of the load taken by the synchronous motors driving the generators of the testing department. Any increase of the load in this department increases the current in the line, consequently increases the ohmic or resistance drop without the proper compensating effect in the wattless currents taken by the rotary. Any variation also of the phase relations of the synchronous motor load will still further disturb the proper combination of the ohmic and inductive drop on the line, the sum of which two quantities should be, by the action of the rotaries described above, rendered a constant independent of the load. To make the rotaries take leading or lagging currents which shall balance out the disturbing effects of the synchronous machines the following system has been devised, this being, as mentioned above, a modification of Mr. Rice's recent patent. The rotary shunt fields, as shown at *D D* in the accompanying diagrammatic illustration, are excited from a separate direct current 'bus bar which is fed with current from the main 'bus through an auxiliary exciter *A*. This auxiliary exciter serves to raise the voltage across the rotary fields, and is driven by an alternating current synchronous motor of the same number of poles, thus keeping its armature in step with the alternating system. It has no field exciting winding, but its armature is fitted with three collecting rings into which alternating current may be introduced from the secondaries of three small series transformers shown at *B*, the primaries of which are inserted in the lines feeding the synchronous motor *C*, and any other loads supplied over the same transmission line, with the exception of the rotaries. The armature of the auxiliary exciter is coupled to the synchronous motor at such an angle that the currents introduced from these series transformers, when the load passing through their primaries is of unity power factor, tend to set up a field of force in the magnetic circuit of the auxiliary exciter and build up a direct current voltage across the brushes thereof; thus the greater the load on the system *C*, the greater is the boosting action of the machine *A*, and the greater in consequence is the voltage across the field windings, *D*, of the rotaries. Further, if the load on the system, *C*, becomes lagging, tending thereby to still further increase the drop on the transmission line, the currents entering the armature of machine *A* lag also and excite to a correspondingly greater extent the field magnetic circuit of that machine, causing a greater current in the winding *D*, of the rotaries which, in turn, causes the armatures of the rotaries to take a leading current to cut down their excitation, this leading current balancing the lagging current of the load, *C*, and preventing any deleterious effect on the line drop. Vica versa, leading currents of the load, *C*, cut down the voltage across the shunt fields of the rotaries, *D*, causing lagging currents to enter the armatures thereof, which balance the leading currents and equalize their effect on the transmission system. In this way the load on the system, *C*, can vary in magnitude or phase relation by any amount within limits without affecting the voltage relation at the direct current terminals of the rotaries.



REGULATION BY LEADING AND LAGGING CURRENTS.

---

*See *The Electrical World*, February 12, 1898, page 219.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of
Electricity and Transmission of Power.

Official Organ of the Pacific Coast Electric Transmission Association.

Subscription invariably payable in advance. Terms—Domestic, One Dollar per Year; Foreign, Two Dollars per Year. The trade supplied by the San Francisco News Company. Advertising rates furnished on application.

GEO. P. LOW, : : : Editor and Proprietor

PUBLICATION OFFICE:
320 CALIFORNIA STREET,
ROOM 14.

Address all communications to
Editorial rooms, 427 TENTH AVE.
Telephone, "Steiner 627."

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME VII FEBRUARY, 1899 NUMBER 2

EDITORIAL.

WE ARE BUT FINITE BEINGS.

The notorious inefficiencies of by far the greater varieties of illumination now in use, whether they be the open gas flame or the incandescent electric light, presages the time when science shall have rendered present methods obsolete. It is not supposable that steam engineering is to sit idly by and rest content with a condition of affairs which permits ninety per cent. of the energy of fuel to go up the stack, or that electrical engineering will forever continue on with the burlesque of running great so-called electric lighting stations ostensibly for the purpose of supplying light from the ubiquitous incandescent lamp, but in reality supplying some ninety odd per cent. of heat, and the balance, say six or eight per cent., in light. Lighting stations indeed; far better that they be called *heating* stations!

But what shall we say of the gas business, which is further along in years and ought to be the wiser? It submissively worships intermittent processes, which blow living volcanoes of flame heavenwards to warm the moon, and then enhances the monstrous loss by giving light from the open gas jet that is more inefficient as a source of illumination than even the incandescent electric lamp. There is some hope for the gas industry, however, as in truth there may be for the other banches of engineering science, for gas engineers have developed the highly efficient mantle which throws to the winds the paltry four or five per cent. in light efficiency of the gas jet in order to utilize to a far larger extent the ninety-five per cent. or so of heat which constitutes the energy of the open gas flame. This is eminently in the right direction, so far as the utilization of gas for purposes of illumination is concerned, and electric lighting industries have learned well the lesson that in the incandescent gas mantle is found a source of illumination which is neither to be ignored nor crowded out. And now a physicist, following the lead of the Welsbach success, has developed an incandescent electric lamp —the "Nernst" lamp—in which a rod of rare earths in the open air is rendered incandescent by electricity, with the result (so the inventor claims) that incandescent electric light is produced with one-third the consumption of energy required in the ordinary incandescent lamp.

Incandescent lamp development is working out its evolution slowly, very slowly, it seems. First came the ordinary incandescent electric lamp with its high resistance filament of carbon which reaches a high degree of brilliancy, and consequently a high efficiency as an illuminant, only when closely approaching the dangerous point of dissipation. Next came the incandescent gas mantle, which, like the incandescent electric lamp, derives its light-giving properties from heat. But the oxides of the rare earths used in the manufacture of incandescent gas mantles are superior to the carbon filaments of incandescent electric lamps in that the mantles are capable of being operated at higher temperatures, and consequently at higher incandescence, than the filament without vital risk of dissipation or serious danger to its life. In the Nernst lamp has been made a distinct advance over the carbon filament in that incandescent material is the superior to incandescent carbon, as commercially operated, as an illuminant—but the Nernst lamp has not yet passed beyond the laboratory stage.

Vauntful indeed are we of the electrical industry over the mighty achievements of our forces in their commercial conquests. But while we have cause to congratulate ourselves in some regards, should we not find time to pause and reflect that we are but groping darkly in the realms of science? That with all our boasted enlightenment we can not show that we are sufficiently masterful of the laws of science to enable us to turn to more useful account more than six or seven units of every one hundred that we make for purposes of incandescent electric illumination? That we are deplorably extravagant of nature's forces, and that it is only nature's immeasurable bounties and our own infinitesimal capacities that enable us to continue on in our narrow way of woeful waste? We are but finite beings! Our boasted conquests over science are but braggadocio, and so weak and paltry are our works that the generations of even the coming century will look back in wonderment at our ignorance.

POPULARIZING AUTOMOBILES IN EUROPE.

Mr. Jules Buse, an electrical engineer of Ghendt, Belgium, and who is well known in engineering circles throughout the continent, writes to Prof. Van der Naillen, of San Francisco, that notary Poelaert, of Brussels, has recently placed his official seal on the articles of incorporation of the "International Electrical Postal Society," which has been organized for the purpose of establishing along every public road, a series of electrical charging stations for the purpose of charging the storage batteries of automobiles traveling along these roads. The society was incorporated with a capital stock of eighteen million francs and its principal office is to be at Brussels.

The charging stations will be about ten miles apart and each will have the very best of accomodations not only for electrical automobiles, but also for bicycles and automobiles operated by petroleum. Each station will also contain, as an adjunct, a restaurant, medical service, a repair shop, a depot for petroleum and other necessary oils, and a complete assortment of duplicate parts of all machines. The first system to be established will cover all the first class highways of Belgium and France, and construction on the first line, which is to be commenced immediately, is to be along the government road from Brussels to Paris.

The execution of the program of the society seems to be destined to cause an unprecedented development in the newest line of electrical industry, namely, in the building of automobiles, and the American companies that have been organized to build will surely be among the first to receive benefits from the demand for automobiles that this praiseworthy project is bound to create throughout Europe.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

COST OF STEAM POWER.

A correspondent takes exception to the criticism which was made in the leading editorial in our January issue, as to the cost for fuel and labor for a 1200 horse-power steam plant, given by Prof. C. G. Baldwin as $113,000, and insists that this figure is not too low.

Assuming that a pound of oil will evaporate 12½ pounds of water, which is a thoroughly safe assumption, and that a horse-power may be obtained with a consumption of 20 pounds of steam per hour in the cylinders, it would require 40,820 barrels of oil to produce the 1200 horse-power for the year of 280 days, of 24 hours each. This oil at $1.50 per barrel would cost $61,230 and attendance in such a plant would figure about $8000, making a total of $69,230.

Taking the figures given by Dr. Chas. E. Emery in his paper read before the American Institute of Electrical Engineers on the cost of steam power, for a compound high speed condensing plant, the fuel bill would figure out $61,347, which checks very closely with the figures as based on evaporation and steam consumption.

We still feel that we are justified in saying that the labor and fuel cost of such a plant would be nearer $65,000 than $113,000.

MISTAKES WILL HAPPEN.

Our worthy contemporary, *The Mining and Scientific Press*, reprints verbatim the article on "Electricity in Mining," appearing originally in these columns in April last—which reproducting is eminently proper—but in doing so, it, through an evident oversight, attributes its authorship to *Electricity*, and not to The Journal of Electricity, as should have been done.

By the way, the article referred to seems to have been favorably received by mining interests. It was also reprinted in the *Mining and Metallurgical Journal*, which gave it a radical endorsement in the statement that "miners interested in electrical power will find this article well worth preserving."

And now, as if to show how easily "mistakes will happen," apologies must be extended to the *Street Railway Journal*, for the inadvertance by which the abstract of the article by Dr. Louis Bell on "Rotary Converters in Railway Work," appearing on page 14 of the present volume of The Journal of Electricity, was accredited to the *Street Railway Review*. This excellent article was reprinted from the former publication—not the *Review*.

PHASE INFLUENCES ON ROTARY CONVERTERS.

Steinmetz has contributed an article to *The Electrical World*, (Vol. XXXII, page 650), on "The Converter," which points out among many other valuable features, that the more phases there are to the alternating current supplied to a rotary converter, the less is the heating of its armature coils. It is shown from tables given that, assuming an internal energy loss of four per cent., and assuming unity as the power factor of the incoming current, a 100-kilowatt rotary must be limited, for the same copper heating, to a rating of 82 kilowatts, if used as a single-phase converter, but it may be run at 131 kilowatts with three-phase supply, at 161 kilowatts with four-phase supply (commonly known as two-phase), at 194 kilowatts with six-phase supply, and at 231 kilowatts with as many phases as there are commutator segments. These figures are, of course, based on the use of commutators properly proportioned for the increased load.

TWO ILLOGICAL CONDITIONS.

Advocates of municipal ownership, as well as those members of the electric lighting industry who decry the importance of the Welsbach mantle as a competitor of the electric light, will find little consolation from the experience of the corporation of Liverpool, England, which, it is reported, has found it more economical to light the streets of that city by means of Welsbach incandescent gas lamps than by electric light, despite the fact that the corporation operates an electric lighting plant for municipal purposes, while gas is furnished by a private company. Municipal ownership is as illogical as is antagonism between gas and electricity, and *vice versa*.

SAN FRANCISCO RANKS THIRD.

Messrs. Hale and Codman, have contributed to *The Electrical World* (Vol. XXXIII, page 19), some statistics they have gathered on the relation between the use of electricity and the population of the principal cities of the world, from which it appears that the central station capacity of San Francisco, when reduced to 16 candle-power lamp equivalents, is such that it has 598 lamps to each 1000 inhabitants. Rochester, N. Y., and Boston alone lead it, they having respectively 982 and 836 lamps per each 1000 in population. Should the capacity of isolated plants be added to that of the central stations, San Francisco drops to the fifth place, the figures then reading: Boston, 1232 lamps; Rochester, 1040 lamps; New York, 859 lamps; Chicago, 730 lamps, and San Francisco, 660 lamps per 1000 inhabitants.

Gas

ACETYLENE.*

BY PROF. VIVIAN B. LEWES, F. I. C., F. C. S.

III.

IN the generation of acetylene from calcic carbide and water all that has to be done is to bring these two compounds in contact, when they mutually react upon each other with the formation of lime and acetylene, while if there be sufficient water present the lime combines with it to form calcic hydrate.

I:

Water H_2 O Lime

×

Calcic Carbide Ca C_2 Acetylene

and II:

Lime	Water	Calcic Hydrate
CaO	H_2 O	$Ca(HO)_2$

GENERATORS.

There are manifestly two methods by which the carbide and the water can be brought together, either by adding water to carbide or carbide to water, while a slight amount of novelty can be introduced by allowing the water to rise in contact with the carbide from below, *i. e.*, by bringing the water to the bottom of the carbide instead of to the top. In considering the various forms of acetylene generators it will be well to divide them in the first place into two classes: (1) The automatic, in which the storage capacity for acetylene is less than the total volume of gas the charge of carbide is capable of generating, and which depends upon some special arrangement for stopping the action of water on the carbide when the consumption ceases. (2) The non-automatic, with which there is a holder of sufficient size to contain the whole of the gas generated from the charge of carbide which is used.

Each of these classes may be subdivided under three heads:

(*a*). Those in which the water is, by various devices, allowed to drip or flow in a thin stream on to a mass of carbide, the evolution of the gas being regulated by the stopping of the feed water.

(*b*). Those in which water in volume is allowed to rise in contact with the carbide, the evolution of the gas being regulated by the water being driven back from the carbide, by the increase of pressure in the generating chamber, or by the rising bell of the gasholder drawing the carbide up out of the water.

(*c*). Those in which the carbide is dropped or plunged into an excess of water.

The points to be attained in a good generator are: 1. Low temperature of generation. 2. Complete decomposition of the carbide. 3. Maximum evolution of the gas. 4. Low pressure in every part of the apparatus. 5. Ease in charging and in removal of the residues. 6. Removal of all air from the apparatus before generation of the gas.

When carbide is acted upon by water considerable heat is evolved, the intensity of the temperature developed depending on the time needed to complete the action. The decomposition of the carbide by water is extremely rapid, and the degree of heat varies with every form of generator, so that while the water in one form may never reach the boiling point of water, the carbide in another may become red hot and give a temperature of over 800° C. When water drips upon carbide, as in generators of division *a*, the temperature rises rapidly until it reaches a maximum in about eighteen or twenty-five minutes, the actual heat developed depending upon the rate of flow of the water and the way in which it is distributed over the mass. But it is quite possible with generators of this class to reach from 400° C. to 700° C., and it is probable that in some parts of the mass the higher limit is nearly always attained.

Makers of automatic generators seem to think that all they have to do in order to stop the evolution of acetylene is to cut off the water supply, but instead of stopping then it continues to be evolved, although with increasing slowness for a considerable time. The results of experiments on this point show clearly that in any apparatus operating on this principle the cut-off should be arranged so that at least one-fourth of the total holder capacity is still available to store the slowly generated gas.

According to theory, 64 parts by weight of carbide require only 36 parts by weight of water to completely decompose them and convert the lime into calcic hydrate. This means that each pound of carbide requires a little under half a pint of water to complete the action, but in practice, owing to the evaporation due to the heat of the action, half the added water is driven off as steam with the acetylene or left mechanically adhering to the lime, and the smallest quantity likely to complete the action would be a pint to a pound of carbide, while in reality the only safe way is to add enough water to drown the residue.

The second subdivision of generators (*b*) in which water rises to the carbide, is very popular, and overheating can be avoided in these provided they are so arranged that the water is driven back from the carbide and that the charge of carbide used is not too great. Under these conditions, the slowly rising water is always in excess at the point where it decomposes the carbide, so that the evaporation by rendering heat latent, keeps down the temperature, and although the steam so formed partly decomposes the carbide, in the upper portion of the charge, the action is never sufficiently rapid to give any very great rise in temperature. In the best generators of this class it is unusual to find that the melting point of tin, 228° C., has been reached in the carbide during decomposition. Where apparatus of this class are automatic and have no rising holder to take care of the gas, they work satisfactorily when supplying the number of lights for which they were designed; but if they are over-driven and the action becomes too violent, excessive heating takes place, while the turning off of the gas and consequent driving back of the water from the carbide also has a tendency to it. If, however, the water has risen sufficiently slow, the carbide below the surface has been practically all decomposed, so that the heating only takes place over a limited zone.

The generators of subdivision *c* are the worst offenders as regards excessive heating, the charge of carbide in some of them frequently becoming red hot, while the lime taken from them is highly colored, and often black, from the formation of tar and carbon.

The moment acetylene is subjected to the action of high temperatures, changes of great complexity begin. These are at first purely synthetical. At temperatures which are comparatively low, the acetylene begins to condense to benzine. As the temperature rises, the condensation of four molecules of acetylene yields styrolene. A further increase in the temperature may cause the benzine and styrolene to interact, yielding anthracine and hydrogen; and it is probably at this point that the brown tar vapors appear, while napthalene is also formed. At this temperature, moreover, a fresh set of interactions start. The nascent hydrogen combines with acetylene to form ethylene, and this body, under the action of heat, breaks down into methane and acetylene once more. In generators in which excessive heating takes place, the tar is very likely to cause considerable trouble, but a still more important evil is to be found in the alteration which takes place in the composition of the gas, and which reduces its illuminating power to a considerable extent. A sample of gas taken while the charge in one of these generators was over-heating, gave the following result on analysis: Acetylene, 70.0 per cent.; saturated hydrocarbons, 11.3 per cent.; hydrogen, 18.7 per cent. Such a mixture has only about one-half the illuminating value of pure acetylene.

At first sight these results seem an absolute condemnation of the second subdivision of apparatus; and the rising bell which draws a mass of wet carbide above the surface of the water should be at once discarded, as it is bad from every point of view. But generators in which water rises from below and so attracts the carbide, can be made safe if the arrangements are such that the water can never be driven back from the carbide, and the bulk of the carbide is sufficiently subdivided.

---

*Abstract of a series of four Cantor lectures delivered to the Society of Arts, London.

The generators of the third class, although exhibiting great advantages in that their form renders it impossible to get above a temperature of 100° C., so long as there is water present, has the drawback of being the least economical in the output of acetylene per pound of carbide used, as the gas, having to bubble through the water, is rapidly dissolved by it, while in an apparatus in which only the surface of the water touches the gas, the amount dissolved is small, The result of this is that with generators of this class the generation rarely exceeds 4.2 cubic feet of acetylene per pound of carbide, instead of over 5 cubic feet per pound.

In generators of the first subdivision there may be a small quantity of the carbide left undecomposed, if water enough to flood the residuum be not admitted, while in non-automatic generators of the second subdivision this is practically impossible. In generators of the third subdivision, in which carbide drops into a large excess of water, is found the worst offender in this respect, for, if the generator has been in action for some time, a thick sludge of lime collects at the bottom of the generator, into which the carbide sinks, and a large lump of carbide will often bake for itself so tough a layer of oil and lime that it resists the action of the water, and is found unacted upon when the generator is cleaned out. The usual explanation given by the generator maker is that it is crust present in the "bad carbide." In a good generator the maximum yield of gas should be evolved from the carbide, but it is a fact that if you take a number of different machines and supply them all with exactly the same carbide, no two will give the same yield of gas, the best generators giving volumes approximating 5 cubic feet per pound of carbide, while the worst will give barely 4 cubic feet, a result; as usual, placed at the door of the carbide.

The causes which tend to diminish the volume of acetylene given off are:

1. Undue pressure in the generator.
2. The acetylene after generation having to pass through water.
3. Undue heating, causing polymerisation.

The first, which is very noticeable, is due to the increased volume of gas dissolved by water under pressure. Although 10 volumes of water at atmospheric pressure only dissolve 11 volumes of acetylene, at two atmospheres pressure it dissolves double the quantity. When acetylene is generated above the surface of water, but little dissolves at once, the top layer of water rapidly becoming saturated; but when the gas has to bubble up through a mass of water, as in generators of the third class, a heavy loss from solution takes place. The pressure in all parts of a generator should be as nearly equal and as low as possible, and this is best obtained by working freely into a gas holder of sufficient size. I think it is a mistake to allow more than 20 inches as the limit of permissible pressure in generators.

One pound of pure calcic carbide yields 1.15 pounds of slacked lime, and experiments made show that one pound of carbide will yield eight pints of lime sludge, which can be got rid of by a sludge cock at the bottom of the apparatus.

As to explosiveness, working with 90 litres of the various mixtures of acetylene and air in an explosion cylinder, and measuring the pressures by means of a manometer and indicator, the results given in the following table were obtained, the first column giving the percentage of acetylene in the mixture with air, and the second giving the pressure of the exploding mixture in atmospheres.

ACETYLENE.	PRESSURE.
2.5 per cent.	0.5 atmospheres
3.7 "	3.7 "
4.7 "	4.9 "
5.5 "	5.2 "
6.6 "	6.8 "
7.7 "	8.2 "
8.3 "	8.6 "
9.1 "	9.7 "
10.0 per cent.	11.1 atmospheres
11.1 "	11.1 "
12.5 "	10.6 "
16.6 "	7.2 "
20.0 "	16.0 "
25.0 "	16.9 "
33.0 "	18.4 "
50.0 "	20.3 "
66.0 "	10.0 "
80.0 "	6.3 "

If a mixture of equal volumes of acetylene and air be ignited in an open cylinder 18 inches high, a lurid disc of flame runs down the cylinder, and a vast cloud of carbon is given off, but no sign of explosion occurs. If, however, this is done in a closed vessel, the very slowness of the combustion brings about the explosion, as the combustion of the portion of the mixture first ignited creates a pressure under which the remainder detonates at the temperature of combustion, and given the high pressure noted. I have found it extremely difficult to ignite such a mixture by means of an electric spark, but if a flask is employed to that there is a considerable volume of the mixture present, the spark at once causes a violent explosion.

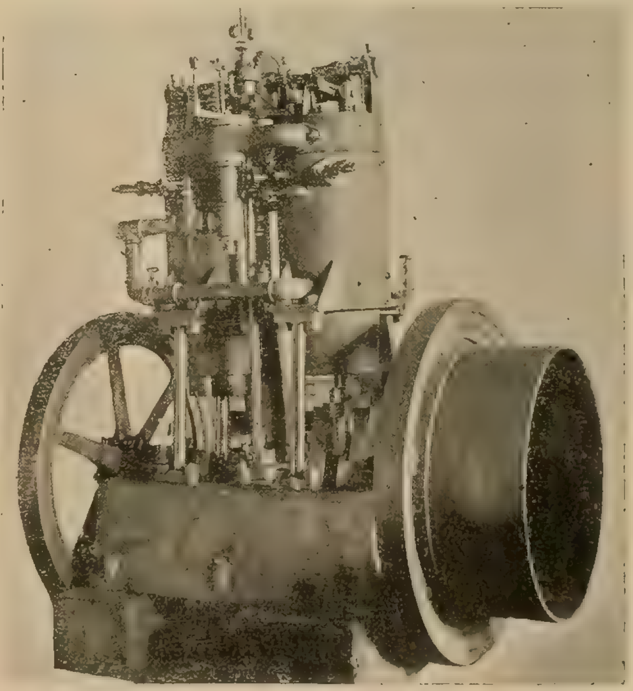
An analysis by Dr. Wolff of acetylene generated from American carbide as at present made, gave the following: Phosphoretted hydrogen, 0.05 per cent.; sulphuretted hydrogen, 0.08 per cent.; ammonia, 0.08 per cent.; hydrogen, 0.09 per cent.; nitrogen, 0.42 per cent.; oxygen, 0.87 per cent.; acetylene, 98.41 per cent.

(*To be concluded in March number.*)

RECENT USES OF THE GAS ENGINE.

BY CHAS. H. F. LÜBCKE.

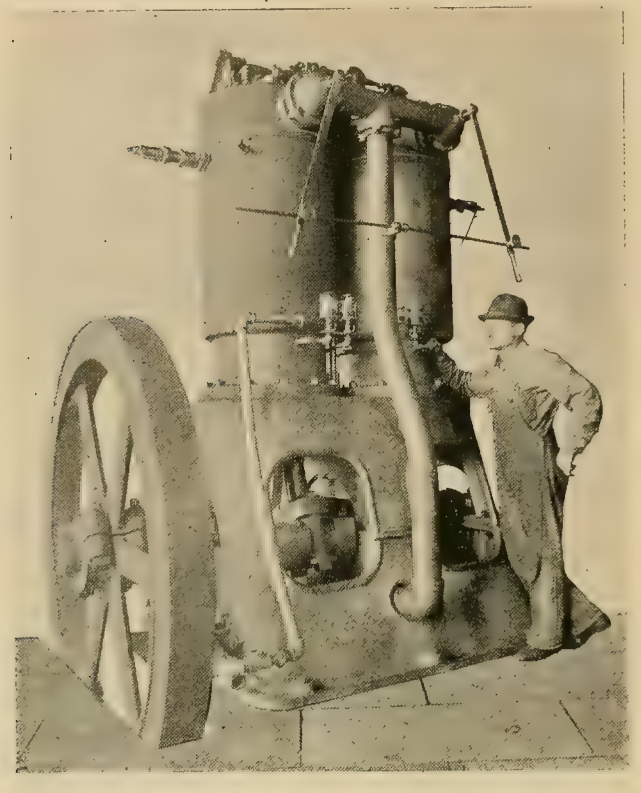
It may be of interest to quote a few instances where the gas engine has effectually taken the place of steam power. Recent developments carry the conviction that the gas engine is advancing and gaining valuable ground in the manufacturing industries as a prime mover, and that it may oust its rival, the steam engine; for, is there not found in the gas engine a solution for the problem of obtaining power from heat in the simplest way? That this is true is proved by the increased economy realized in using the gas engine.



A CALIFORNIA-BUILT "MARINE TYPE" GAS ENGINE FOR DYNAMO DRIVING.

About a year ago it was found necessary to install an electric light plant at the Ingleside racetrack, San Francisco. After due consideration the gas engine was adopted as the motive power. The engine was built by the California Gas Engine Company, of San Francisco, and the dynamo was of a familiar multipolar type. The engine has four cylinders, and as it is constructed on the Otto four-cycle type, it receives one impulse every stroke. The engine when running normally develops fifty horsepower. The dynamo is driven by a belt, from a pulley located on the center of the engine shaft, two cylinders being on each side of it. The strain of the shaft is, therefore, very evenly balanced.

It may be easily shown that this engine has advantages over the single cylinder fifty horse-power gas engine. The equivalent of fifty horse-power in heat is distributed to four cylinders, therefore each cylinder will be much easier to keep cool, the strain on the metal will be less, and the initial pressure will be expanded down further than is the case with the single cylinder engine. Furthermore, the strain on the crank shaft is more even, a very decided advantage in gas engines. Also the weight of the flywheels may be made considerably less. The engine is supplied with a throttling governor, which regulates the speed at 2¾ per cent.



A CALIFORNIA-BUILT GAS ENGINE FOR MARINE USE.

The ignition of the gases is accomplished by the electric spark, now most commonly used in America. The electric spark is introduced into the cylinder by the Woltenbaugh patent igniter. This igniter has the advantage over the common spring igniter in that a solid musket steel point produces the spark. This steel point connects by a rod to a spiral steel spring outside the cylinder. The spring being outside, it is not affected by the heat in the cylinder; furthermore it is always in plain sight, and the tension of it may be adjusted by hand while the engine is running.

The output of this plant is 300 sixteen-candle-power incandescent lights and 20 arc lights, the dynamo furnishing current at 110 volts. It may be stated here that the variation in the current does not exceed three volts. One attendant operates engine, dynamo, and switchboard, as the engine requires no more attention than filling the oil cups. This plant is in successful operation, and furnishes light at one-eighth gallon of gasoline per horsepower per hour. This fact may well be noticed and be compared with the amount of fuel burned under the boiler of a modern steam engine. There are many other cases where the gas engine has superceded the steam engine, principally where small power is required.

During the summer the same company supplied Mr. George Oulton, of Twitchel Island (Sacramento river), with a fifty horsepower, vertical, double cylinder, marine type engine for reclamation purposes. The gas engine operates by belt a fifteen-inch centrifugal pump, throwing 10,000 gallons per minute. The elevation is fifteen feet. This engine, as indicated by the name "marine type," is an ideal marine or boat engine. It is not closed in like most vertical gas engines, but has cast iron columns at the back and polished steel columns in front, supporting the cylinders. All working parts, that is, connecting rod, and crank pin brasses are in plain sight, well adapted, and provisioned effectively with lubrication. This engine is furnished also with a throttling governor, Woltenbaugh igniter and sparking dynamo.

The best gas engines are now furnished with an adjustment for timing ignition while the engine is in motion. It is of vital importance that the gases in the cylinder should be ignited at the proper time to insure complete combustion, thus giving the utmost economy in the operation of gas engines. As found by extensive trials, the instant of ignition, to insure the best results, occurs just before the crank arrives at the upper dead center. Now any engine supplied with the ordinary fixed sparking arrangement, will not start if the spark is set ahead of the center; it will simply kick back and try to run the wrong way. It was therefore found necessary that a means should be provided by which the engine will start with the spark set at, or a little after, the center; but when the engine is running the igniter may be manipulated so as to set the spark earlier, to any point desired, in relation to the crank.

There has been, and there still is, a great prejudice among the public that the gas engine is unreliable and very easy to get out of order. Let me say to those who still entertain the prejudice, that if one half as much care was exercised in handling the gas engine as is now done with boilers and steam engines, all the unreliability of the gas engine would vanish, and it would occupy today the front rank of all motive powers. Manufacturers of gas engines, both in this country and in Europe, are improving their engines steadily, and they are very often greeted by success. With all respect for the steam engine, the gas engine has come to stay, and why? Because it delivers the horse-power per hour cheaper than is done by the most modern steam engines of today.

DIESEL MOTORS AND OTTO GAS ENGINES.

If we are to judge by remarks recently heard in a conversation on internal combustion engines, the difference between the operation of the Diesel motor and the Otto gas engine does not appear to be generally understood. The first stroke of the Otto gas engine draws a mixture of air and gas into the cylinder, the second stroke compresses it, at the beginning of the third stroke it is exploded, and during the third stroke the piston is driven forward as the result of the explosion, while the fourth stroke expels the burned gases from the cylinder. The operation of the Diesel motor is entirely different. The first stroke draws air into the cylinder, the second compresses it to 600 pounds per square inch, at the commencement of the third stroke oil is forced into the cylinder against the high pressure by means of a small auxiliary pump driven by the engine and is immediately exploded by the heat generated by the compression, the piston is driven through the third stroke by the force caused by the burning oil, and the product of combustion is expelled during the fourth stroke. The air compressed by the pump referred to is also used in starting the engine, and this gives the Diesel motor an advantage over others by being always ready to start. The consumption of petroleum, according to Prof. Scroter in a paper read before the Institution of Civil Engineers, (England) last year, is 0.524 pound per brake horse-power, and 0.396 pound per indicated horse-power hour.—*American Engineer and Railroad Journal.*

Personal

MR. A. J. COFFEE has been appointed Pacific Coast agent of the Gamewell Fire Alarm Telegraph Company, vice Mr. R. A. Rose, resigned.

MR. SIDNEY SPROUT has been appointed superintendent of the famous Rawhide mine, the duties of which position will consume his entire time, and necessitates his removal to Sonora, Tuolumne county, Cal.

MR. WALLACE W. BRIGGS has resigned the electrical engineership of the San Francisco office of the Fort Wayne Electric Company to accept a position as salesman with the Westinghouse Electric and Manufacturing Company at San Francisco.

MR. JOHN W. BROOKS, founder of the Brooks-Follis Electric Corporation, and now western sales manager for the Fostoria Incandescent Lamp Company, was married to Miss Winifred Cole, the charming and accomplished daughter of Mr. and Mrs. N. P. Cole, of San Francisco, on January 10th. The happy couple left for Chicago immediately after the ceremony, and the congratulations of hosts of well-wishers, including THE JOURNAL OF ELECTRICITY, have accompanied them to their new home.

MESSRS. EDWARD H. BENJAMIN, mining engineer, A. M. HUNT, mechanical and hydraulic engineer, and WYNN MEREDITH, electrical engineer, have become associated for the purposes of general consulting, constructing, and supervising engineering, with offices at 331 Pine street, San Francisco. Mr. Hunt, of the late firm of Hasson & Hunt, and more recently chief engineer of the department of navigation of the Alaska Commercial Company, is by far too well and favorably known throughout California to require further introduction, while Mr. Benjamin, who is secretary of the California State Miners' Association, is one of the most able mining engineers in the west. Mr. Meredith, who has won for himself a high standing in the electrical and transmission field, was associated with Mr. Sidney Sprout as assistant to the chief of the operating department of the World's Columbian Exposition, at the termination of which they came to San Francisco, serving as assistant electrical engineers of the Midwinter Fair. Mr. Meredith then became electrical engineer for the late firm of Hasson & Hunt, where he remained until its dissolution some months since. The new engineering association is the strongest that has yet been formed, and its personnel presages the opinion that it will become a potent factor in western engineering developments of the near future.

Literature.

"Commercial Cuba; a Book for Business Men," by William J. Clark, with an introduction by E. Sherman Gould, Mem. Am. Soc. C. E.; 514 pages, 6¼x9½, octavo, cloth, with eight maps, plans, and 40 full page illustrations and a commercial directory appended. Published by Charles Scribner's Sons, New York, 1898. Price, $4.00.

This timely work is read with the same interest with which one listens to after-dinner tales of adventure from the lips of some traveler of renown. It reads like a book that was "talked-off," not written, and in consequence, much of a statistical or encyclopedic nature is interwoven with descriptive matter in a style that both interests and instructs. However desirous the reader may be in learning of the social customs and civilization of our Cuban proteges, he cannot do otherwise than become impressed with the commercial possibilities of the new Cuba, for the author has packed the book with facts gathered from personal observation and official reports, that give exhaustive information concerning the condition and possibilities of every industry on the island, each town and district being critically examined with a view of presenting authentatively the outlook for American capital, backed by American energy. The chapters deal with social and hygienic questions, legal procedure, political matters, public improvements, railways, both steam and electric, turnpikes and roads, harbor and dock facilities, telegraph, cable and telephone lines, contract labor, agriculture, mining and manufacturing in all of its branches, and a multitude of other subjects of interest to business men who are looking to Cuba as a field for investment or as a market for goods.

One cannot but be struck with the enormous energy and unbounded resources displayed by the man who, in the brief time that has been at his command since a commercial interest in Cuban affairs has been awakened in the United States, has written and compiled the exhaustive work now in hand, and has done it with a painstaking thoroughness that ordinarily would have consumed years of travel, writing and compilation. Mr. Clark's wide experience in foreign commercial affairs, however, peculiarly fits him for the position he occupies, namely, that of general manager of the Foreign Department of the General Electric Company, with headquarters in New York City, which fact renders the book of the greater interest and value to electrical readers.

Hydraulics

ELECTRIC UTILIZATION OF WATER FALLS.

THE first item of expense in electrically utilizing a water power is the amount required for water privileges. In some cases this is rather an unimportant consideration, while in others it is the chief expenditure, for it may involve the buying of thousands of acres of land surrounding the stream, because the necessary dams may cause to be submerged a great deal of valuable land, or large tracts have to bought for building storage reservoirs, or the right of way for pipe lines, etc., have to be secured. When land is cheap these considerations are often not objectionable, but where good farming land, or land valuable for other reasons, has to be thrown to waste, the question may be a very perplexing one.

The cost of the dam, power house, and hydraulic machinery is, as a rule, dependent almost entirely on the characteristics of the stream that is being utilized. Entering into the question is the amount of water in the stream, both under normal as well as abnormal conditions at various seasons of the year; also the head or fall, and whether it is dependent on natural conditions or requires the building of large dams. Generally speaking, other things remaining equal, generating plants, comprising the power house, hydraulic and electric machinery, as a whole cost less as the head increases, until certain limits have been reached. When the head is low, ranging from four to ten feet, it requires a comparatively large wheel for a relatively small amount of power, and then only slow speeds can be attained. When large units are desirable, a number of such wheels must be coupled together in order to get the required power. The speed required can be raised or lowered to a certain extent, depending on the size of the wheel. If higher speeds at low heads be desired for large units, many wheels must be operated together, requiring not only a great deal of room, and consequently a larger power house, but considerable line shafting, gears, couplings, etc., which not only increase the initial cost, but increase the cost of operation and maintenance of the plant, as well as introduce another source of inefficiency. With higher heads a larger amount of power can be obtained from fewer and smaller wheels, with higher speeds, and, therefore, cheaper generating apparatus.

The cost of generating apparatus for a given capacity, other things remaining equal, is almost directly proportional to the speed at which it runs, and for this reason it is always desirable to refrain from too low speeds wherever possible.—D. W. MAGIE, in *Cassier's Magazine*.

TO DRILL HOLES IN GLASS.

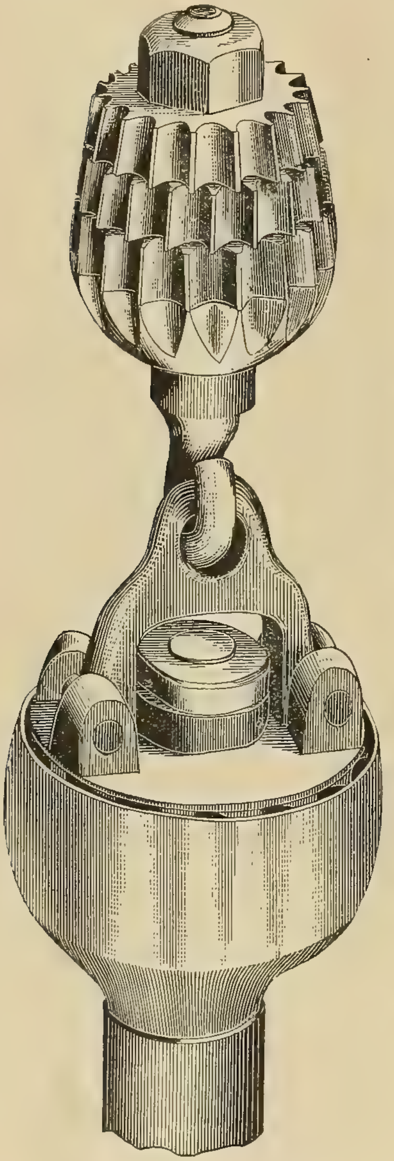
Holes can be easily drilled in glass with an ordinary drill, if the spot is moistened with a few drops of a mixture composed of 25 parts of oxalic acid in 12 parts of turpentine. Keep tightly corked.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

A REMARKABLY EFFICIENT TUBE CLEANER.

EVER since the introduction of water tube boilers they have steadily grown in favor among steam users, but like all other good things, they have their weak points. Their main drawback is the immense amount of time and labor required to keep them clean. The scale will form and burn on to the inside of the tubes, and it is almost impossible to thoroughly remove this scale by any of the crude appliances, such as the different kinds of hand scrapers.



THE "GO-DEVIL" TUBE CLEANER.

The invention of the rotary tube cleaner, driven by water power (the water serving a double purpose of driving the motor and washing out the scale, loosened by the cutters) was expected to be a long step in the right direction, and the immense amount of time and labor required for cleaning water tube boilers was supposed to thus become greatly reduced and the work simplified. However, the first of the cleaners was a crude affair. It required a large amount of water to run the motor, and produced very little power, with a very small cutting or scraping effect. Several improvements were made on this kind of machine, and other machines were invented, all combining the same rotary principle, but none of them have proved efficient. Some lacked power, and all were complicated affairs that wore out too quickly. Some of them were only suitable for straight tubes and even then could not do the work if the scale was hard and thick. All of these imperfections became apparent and were commented upon by engineers in general, which rather gave the rotary tube cleaner a set-back for a time.

The inventor of the "Go-Devil" Tube Cleaner has finally solved the problem of doing quick and efficient work. The "G.-D." tube cleaner is made of brass and steel, fitted with ball-bearings, and is very clearly set forth by the engraving. Four $\frac{3}{16}$-inch conduits supply all the water required to a disc motor, which is fitted with reaction buckets situated close to the edge of the outer circumference of the disk, thus giving the largest amount of power for the smallest amount of water. The speed of this wheel, when subjected to a water pressure of sixty pounds to the square inch, is from 2000 to 4000 turns a minute. The cutter head is made up of three disks of steel, with teeth milled in the edges and set staggering, and when assembled form a sort of pear shaped cutter head of considerable weight.

The operation of this device is somewhat peculiar, in that there are two distinct motions imparted to the pear shaped head or cutter, which can only be described as follows:

First: There is a spinning motion due to the water motor.

Second: A gyrating, roweling, spiraling motion, due to the contact of the teeth in the cutter head on the tubes, and also to the fact that the pear shaped head is smaller than the inside diameter of the tube.

The direction of this gyrating, roweling, spiraling motion is opposite to the spinning motion mentioned, and it has a pounding, beating, and smashing effect, large pieces or flakes of scale being dislodged by its action, the force of which can be regulated by the water supply. It is due to this combination of motions and the weight of the cutter that the "G.-D." tube cleaner shows its wonderful efficiency, speed and thoroughness of work.

One of the most valuable features of the "G.-D." tube cleaner is the ease with which it cleans off scale from the outside of fire tubes in a tubular boiler. To perform this seeemingly impossible work, it is only necessary to change the cutter head, putting on a special cast iron head, hexagonal in shape, which, when entered into the tube and rotated at a high speed, beats and hammers the inside of the tubes, thus cracking off and removing the scale which has formed on the outside of the tube. This should be done when the boilers are opened for cleaning, as the scale is then dry and cracks off easier, the motor being operated by either steam or water, which gives an opportunity for removing the scale, which is thrown down on the boiler sheet; or it can be done while the boiler is under steam, in which case steam is used as the motive power for the driver. For cleaning out the soot and carbon scale in fire tubes, a wire brush is substituted and the motor driven by steam, thus taking out every particle of soot in the tube and leaving it as clean as when new.

It is believed that the "G.-D." tube cleaner will recommend itself to steam users, and a trial of this certainly meritorious device is solicited by the Pacific Coast Machinery Company, Pacific Coast and Hawaiian agents, 12 Fremont street, San Francisco.

TABLE OF CONTENTS.

Illustrated articles are designated by an asterisk (*); Editorials by a dagger (†); Passing Comment by a double dagger (‡), and Industrial by a section mark (§).

Gas

Acetylene—III, by Prof. Vivian B. Lewes, F. I. C., F. C. S. 32
Diesel Motors and Otto Gas Engines 34
*Recent Uses of the Gas Engine, by Chas. H. F. Lubcke 33

Historical

The Heretofore Unpublished Facts of the Pomona Case, by C. G. Baldwin 23

Hydraulics

Electric Utilization of Water Falls 35

Illumination

Nernst's Electric Lamp, by James Swinburne 27
‡San Francisco Ranks Third 31
‡Two Illogical Conditions 31
†We Are But Finite Beings 30

Literature

.... 35

Miscellany

‡Mistakes Will Happen 31

Personal

.... 35

Steam

§A Remarkably Efficient Water Tube Cleaner 36
A Test of California Fuel Oil, by A. M. Hunt, M. E. 24
‡Cost of Steam Power 31
Development of California Oils 25
Fuel Oils of California, by Geo. H. arkin 24

Transmission

‡Phase Influences on Rotary Converters 31
*Regulation by Leading and Lagging Currents 28
*Three-Phase Transformer Manipulation, by A. J. Bowie, Jr. 21

Transportation

†Popularizing Automobiles in Europe 30

THE JOURNAL OF ELECTRICITY.

VOLUME VII. SAN FRANCISCO, MARCH, 1899. NUMBER 3.

The Monterey and Pacific Grove Lighting Plant.

BY HARRY J. BEAN, A. B., E. E.

CALIFORNIA probably contains as diversified an assortment of electric lighting and power plants as is to be found in any state in the union. It has electric transmission power houses that are, in many respects, without equal the world over; it has central stations that are thoroughly metropolitan in every sense of the word; it has steam-driven electric lighting plants operated from boilers burning coal, wood, sawdust, oil, and natural gas; it has water power plants driven under heads varying from six feet to fourteen hundred feet, and it has even projected—the word is used advisedly—electric stations that are to be operated by wave power. Much has been written of all these plants, but, singularly, the type of station most common throughout California, has been overlooked by descriptive writers, and as in it is represented a material factor of the electrical industry of the Golden State, the oversight has wrought an injustice to a very important branch of electric lighting. The similarity in the features of construction and operation of these smaller stations is generally marked, hence but a single one will be described, namely, that of the towns of Monterey and Pacific Grove.

Monterey and Pacific Grove, which are two and one-half miles apart, have only one lighting company between them. This company started to furnish Monterey with lights in May, 1890, and it was not until the early part of 1894 that it established the alternating system by which Pacific Grove is lighted. The power house is centrally located in Monterey city, and is a rough frame building about 60 feet in length and 30 feet in width, with a store front, gable roof, and no floor. The relative positions of the machines, switchboards, boiler room, etc., are shown in Figure 1. The boiler is a two-sheet, fire tube boiler, having a rated capacity of 60 horse-power, the pressure of steam maintained being 90 pounds per square inch. When the engineer wishes to have the steam pressure rise rapidly he sprinkles a little water on the ashes in the ash pit. The pressure gage is plainly visible from where the engineer sits through a hole cut in the door. He regulates the steam pressure, without rising from his seat, by means of what he has termed the "lazy man's damper." This damper is shown in its relative position in Figure 1 and in detail in Figure 2. The pipe enclosing the rod is sunk a little below the floor level so as to be out of the way. The trigger comes out through a slot in the floor near the barrel chair, and by moving the trigger one way or the other the ash pit or draft door can be opened or closed. The engineer moves the trigger with his foot and the ash pit door is furnished with a spring which tends to keep it open.

The boiler room is a room by itself as shown in the first figure. Pine wood, which is in four-foot lengths, is used for fuel, and it is far superior to redwood for steaming purposes as is shown by the fact that pine is used when redwood only costs about two-thirds as much. The engine is a single expansion engine having a rated capacity of 50 horse-power. There are two fly-wheels, one of which contains a centrifugal governor. The length of stroke is twelve inches, and the speed 255 revolutions per minute. A naked steam pipe connects the engine and boiler. The plant is supplied with a small feed pump but it is never used as the head of water from the street main is such as to give 110 pounds pressure per square inch.

Figure 3 shows the oil filter used and in it the oil is filtered through sawdust and a little waste.

The station contains two direct current machines and one alternator, the relative positions of which are shown in Figure 1. The alternator and one direct current generator are belted to one of the fly-wheels, and the other direct current generator is belted to the other fly-wheel, the alternator belt being run on top of the direct current machine's belt, or "tandem."

The alternator is an old T. H. ten-pole machine, originally wound for 1040 volts, but afterward rewound for 2080 volts, but after rewinding it failed to develop 2080 volts until the speed was increased by 200 revolutions per minute. It is now run at a speed of 1800 revolutions per minute, and its capacity is 300 lights. The bearings are oiled by means of feed cups. The two Edison bipolar direct current machines are run at 1600 revolutions per minute and the capacity of each is 250 lights, the voltage at the brushes being 110. The bearings are self-oiling. The lubricant used on the commutator is a patented compound, and there is no sparking at the brushes. The engines and generators are all set upon concrete foundations.

In Figure 4 and Figure 5 are shown respectively the direct current and alternating switchboards, with their connections to the mains and generators. The switchboards are 8 feet square for the direct current, and 9 feet by 4 feet for the alternating current. They are both made of tongued and grooved redwood boards, 5 inches in width and ¾ of an inch in thickness. The direct current board is varnished and the alternating current board is painted white. They are each held about two feet from the ground by means of posts set into the ground. The relative positions of these switchboards are shown in Figure 1.

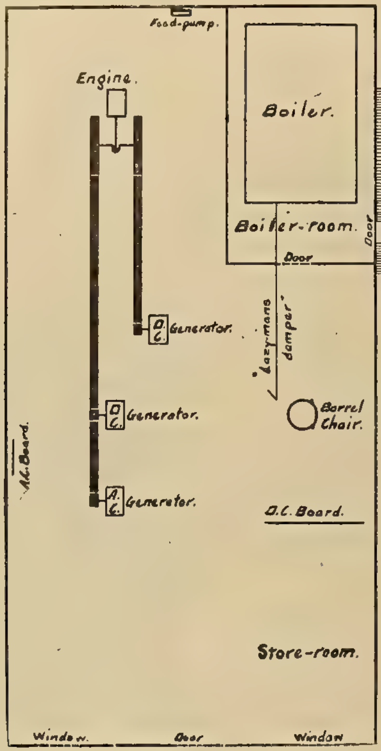


FIGURE 1.

All direct current distribution is by the Edison three-wire system, 110-volt lamps being used on a side. The scheme of alternating distribution appears diagrammatically in Figure 6, from which it will be seen that the primary delivers 2080 volts, either to a single transformer or to two 1040-volt transformers in series. Incandescent service on the alternating circuit is rendered at 105 volts, both by the two-wire and the three-wire system, according to the number of lights. There are six transformers, such as A in Figure 6, between Monterey and Pacific Grove distributing lights by the two-wire system. B, C, and D, in Figure 6, show each two transformers whose primaries are connected in series and whose secondaries are connected to a common or neutral wire between which and the secondary mains the lights are placed, the neutral wire of C being connected to the neutral wire of D. C and D are right across the street from each other in the business center of Pacific Grove. The alternator mains are No. 7 w. p. copper wire and the secondary mains are No. 10 w. p. copper wire.

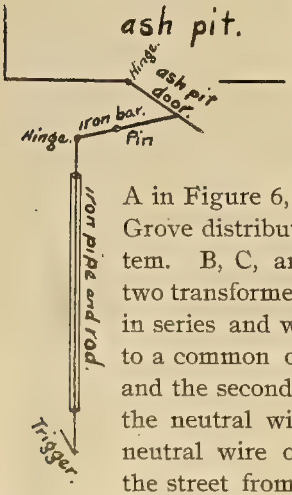


FIGURE 2.

The lightning arresters are screwed up on the front wall of the power house. Figure 7 was drawn on the spot and is a fair representation of the way the connections look. They are all Wurts' lightning arresters, the three large ones being type C and the five small ones style 1383. The company had no lightning arresters until the fall of 1894 when the lightning struck the line and played havoc with the machines. They then put in the three type C arresters, but failed to put in a choke coil by oversight, and the line was struck again in the fall of 1895. The engineer heard the arresters pop and an instant later fire was flying in all directions from the armature. They then put in the five style 1383 arresters and the choke coils. No trouble has been had from lightning since.

The secondary of all the transformers consists of two separate coils which may be joined in series if desired. One of the six, like A in Figure 6, is a General Electric type H transformer, and the potential transformer at the switchboard is type H. One of its secondary coils is connected to the voltmeter and the other to a lamp. Each coil gives 54 volts. All of the others are the General Electric type F transformers. The transformers shown at C in Figure 6 gave some trouble by water getting into them through the holes for the wires. The water short-circuited the coils and the fire and steam quite startled the good people of the town. The engineer placed a tin hood over these transformers and has had no trouble since of that kind. General Electric primary cut out boxes are

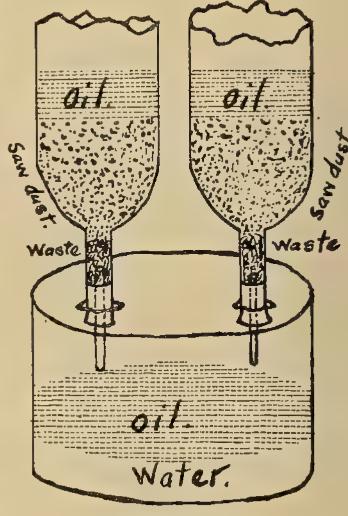


FIGURE 3.

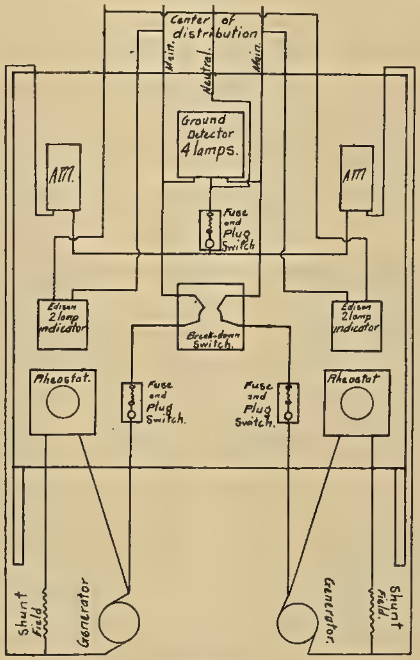


FIGURE 4.

fastened to the cross-arm and the transformers are placed just beneath the cross-arm on the pole. The poles are all 30 feet in length, 10 inches square at the bottom, and 6 inches square at the top. They are placed 5 feet in the ground and 122 feet apart. The top of the pole is peaked so as to form four equilateral triangles. The poles are made of redwood. A gain one inch in depth is made about ten inches from the top of the pole to receive the cross-arm. The cross-arm is made of pine four inches square and five feet long. Four holes are bored in the cross-arms for 1½-inch pins. The cross-arm is placed in the gain and bolted to the pole with two ½-inch bolts. The pins are wooden 1½-inch pins, those in Monterey being oak and those in Pacific Grove being locust. The insulators are of the single-petticoat glass type. The cross-arms are always put on the same side of the pole, no matter whether the resulting strain has or has not a normal component to the cross-arm, tending to pull the cross-arm off of the pole. The poles in Pacific Grove are painted white, except six feet from the ground, where they are painted gray and sanded. The rest of the poles are painted red. The transformers are all fifty lighters. The street lights are of 32 candle-power and the house and store lights are 16 candle-power, all being Edison lamps. The street light hanger, which is made in Monterey, consists of a curved piece of half-inch pipe about four feet in length, on to whose ends are screwed a flange and a reflector. A wire, from the curved part of the pipe to the pole, braces the hanger, the flange being screwed to the pole. The hanger is placed about eight feet from the ground and the reflector is a cone of tin inverted and soldered into another cone of tin which is screwed to the pipe, the lamp being placed at the apex of the cone. The reflector is painted white. The wire is brought down the poles on small porcelain knobs and out along the pipe through clay tubes.

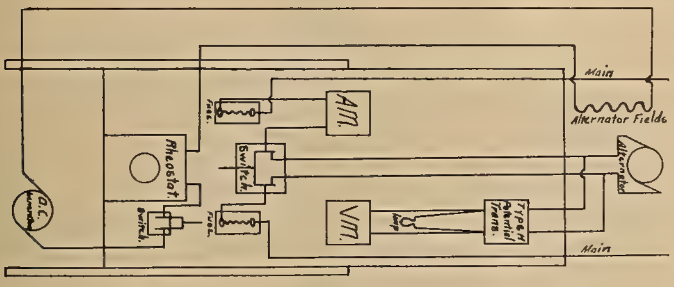


FIGURE 5.

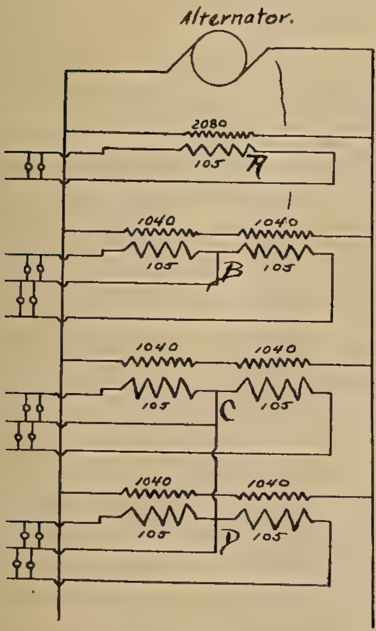


FIGURE 6.

Steam

THE TREND OF CENTRAL STATION DESIGN.*

BY BION J. ARNOLD.

IT has been but little over a decade when the electrical student was told by those who were supposed to be in authority, that to get a reasonable efficiency in electrical machinery, high rotative speed in the moving parts was necessary. While this statement contains an element of truth, it is by no means so important as at first supposed, for our slow speed generators and motors of today are more efficient than many of the high speed machines of that time. Difficulties in the manufacture of heavy electrical machinery and lack of knowledge on the part of the designers of that time were probably the father of the false idea; but be that as it may, the result was to flood the country with electrical plants, consisting of engines, dynamos, pulley shafting and belts, good, bad and indifferent, thrown together in almost any manner. These, however, performed their functions remarkably well under the circumstances, and enabled the youngest branch of the engineering industry to command the brains, energy and capital necessary to revolutionize the transportation and factory methods of our cities and make herself felt in many of the homes of our smaller cities and towns. But since Darwin's law of "the survival of the fittest" applies equally as well in engineering as in natural history, the belts and pulleys are gradually becoming extinct; the engines and generators have left off their prehistoric ear marks and have grown to their responsibilities and to the possession of those elements which make them the bulwarks of electrical industries, the same as the older types of steam engines were to the factories which they drove prior to the advent of electrical transmission. To determine how far this development has gone and its probable tendency in the future, is the subject about to be discussed.

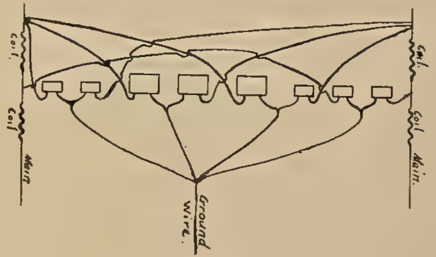


FIGURE 7.

The problem which confronts the power station designer is almost invariably that of the operation of arc lamps, incandescent lamps, and motors for various purposes, with the greatest degree of economy, and with as little expenditure in first cost of plant as possible. This is strictly true of combined lighting and power stations which present the most difficult cases to handle. When, however, the problem is simply one of the development of electrical energy for power purposes only, such as railway work or transmission work, it becomes much simplified. Since the question of the design of a station is interlinked with, and dependent upon the system of distribution adopted, we find ourselves struggling with many of the old questions and some new ones: such as the alternating arc versus the series arc, and the constant potential arc; the polyphase transmission plant versus the direct current; the advisable voltage, either alternating or direct, to adopt for central station work.

While I do not, in this paper, presume to settle these questions, we must necessarily form some idea of their probable solution for general cases, for otherwise we can hardly expect to speculate on "the trend of central station design." The old belted station may be considered obsolete, and we come at once to the general types which have been recently installed by competent engineers, and which may be considered as embodying the latest ideas of those skilled in this class of work. In all of these stations we find certain main parts which may be considered as accepted practice. Of course there are many belted stations running and doing excellent service, which simply speaks well for the engineers and designers, and more especially the manufacturing companies that installed them in the earlier days.

---

*Abstract of a paper read before the Northwestern Electrical Association, January 18, 1899.

The points in accepted practice are:

Water tube boilers, capable of carrying high steam pressures. This probably will be disputed somewhat by the advocates of other types of boilers, and with some reason; but it nevertheless has become almost standard to use water tube boilers in modern central stations.

Mechanical stokers, or improved furnaces or grates.

Self-supporting brick or steel stacks, usually steel. A steel stack can be put up for considerably less money than a brick stack, and for all practical purposes it is equally as good, and can be maintained a sufficient number of years to warrant its adoption in almost every case, if properly looked after.

High pressure steam piping is not duplicated, as was formerly thought necessary by engineers, practice having proven that one single steam header can be divided so as to make a plant reliable if the engines are properly located with reference to the boilers and the header. There are few engineers in the country today putting in plants with duplicate systems of piping, unless in buildings where it seems necessary to do it, and on account of the peculiar location of the engines with reference to the boilers. Steam piping costs excessively in a power station, and the less of it put in the better, because there is then less radiating surface to waste heat and fewer parts to keep up. The diameters of the steam heaters now being placed are somewhat decreased, as compared with those installed four or five years ago.

Large compound condensing steam units. It has become accepted practice to install as large engines as practical, on account of the decreased cost per horse-power and the increased economy of a large engine over a small one. They are almost invariably compound engines, where it is possible to condense, and in many cases whether it is possible to condense or not. The tendency toward triple expansion work is not as strong as it was five years ago, it having been determined that for almost all cases a compound engine will get nearly as good economy as a triple expansion engine, and in many cases just as good; it requires less investment, is less costly to maintain, and the difference in economy of the triple expansion over the compound is so slight that it makes it inadvisable to install, except in exceptionally large sizes. On account of the excessive diameters of the low pressure steam cylinders in large compound engines it is the practice to install triple cylinder compound engines; that is to divide the low pressure cylinder into two smaller cylinders, the combined area of the two being equal to the area of the large cylinder of a single compound engine.

Direct connected generators of large capacity. What has been said in general regarding large steam units applies equally as well to electrical generators, because the larger the unit the greater the economy of the combined unit.

To these chief features of design, which have become so generally accepted as to require little or no discussion, there may be added several features which may be justly called "tendencies" or "trends," which have not yet been universally adopted.

Under the first heading comes *Economizers*. Economizers consist of a series of vertical cast iron tubes carrying water within them and around the outside of which the gases pass from the boilers to the smokestack. There is no doubt but that there is economy in the use of an economizer, ranging from five to seven or eight and sometimes as high as ten per cent. In order to get the benefit of an economizer ample draught must be provided. Sometimes an economizer is installed where the draught is poor, the result being no economy and the annihilation of the draught. There is only one solution for this and that is to increase the height of the stack or introduce mechanical draught to realize the benefits of the economizer.

Mechanical draught. Under this head there are two types: induced draught and forced draught. Induced draught is a device which consists of a large fan or fans driven by steam engines or electric motors, which are placed between the economizers and the smokestack; or, if economizers are not used, between the boiler flues and the smokestack, the object being to draw or suck the smoke from the boilers through the fan and deliver it into the stack. The advantages of the forced draught scheme are, first, a lower and less expensive stack can be used; in fact, no stack at all is required except to get the gases above the buildings in the immediate neighborhood of the property. Second, the fires can be handled under any and all conditions. We are all aware that the condition of the atmosphere changes our draught, and in case a stack is no larger than is required, there are days when it is difficult to hold steam, and it becomes necessary to put more boilers into service than would be necessary if a mechanical draught fan were used. Where the economizers can be installed in connection with induced draught, an economy is always effected.

Then there is the forced draught which consists in blowing air under the grates of the boiler and forcing it up through the fire and into the stack, which is supposed to perform the same function that the induced draught does. The objections to it are that inasmuch as it creates pressure in the fire-box, the gases are liable to escape out into the room and make a distasteful fire room. Otherwise, the results accomplished are practically the same as accomplished with forced draught, and it is considerably less expensive to install, and this is its chief advantage.

Cooling devices. Under this head come cooling towers and cooling tables. In most plants in this country there are probably no facilities or natural opportunities for getting water for condensing purposes, and until recently we have thought it was advisable to continue to operate these plants non-condensing. During the past two years there has been a tendency to put in these cooling towers, and when properly put in there is always an economy effected, resulting in a net saving of fifteen per cent. in fuel. A tower consists of a series of vertical tubes or sheets, usually within a wrought iron frame, through which air is forced by blowers, driven by steam engines or electric motors, and down through which flows, or sprinkles, or is spread, the water from the condensers. The water coming in contact with the air is cooled and accumulates at the bottom of the tower, and is then pumped into contact with the steam and condenses it. The same water is used over and over, so that only from five to ten per cent. will have to be renewed on account of the evaporation. The five per cent. must be added from the city water works, or other outside sources.

In place of the cooling tower, where real estate is cheap and available, a table can be erected, consisting of a series of boards laid gridiron shape, upon which the water is delivered by the condenser pumps and is sprinkled down through the boards, and the air from the atmosphere penetrating through underneath the shelves comes in contact with the hot water and cools it. It then forms a pool at the base of the shelves and is taken from there and pumped back in contact with the steam in the same manner as in the cooling tower. This device can be installed for the same, or less amount than a cooling tower, and it is advisable to install it where there is sufficient real estate to place it upon, because it requires no power to cool the water, and power is required to drive the fan of a cooling tower.

Motor-driven auxiliaries. Many of the most modern plants are equipped with electrically-driven air pumps, boiler feed pumps, and cooling tower motors, if tower is used. There is a question as to whether this is the most economical thing to do or not. Some believe it to be so. Others maintain that the latent heat derived from the exhaust from the steam cylinders of the steam-driven auxiliaries, if run through a surface or closed heater, more than compensates for the wasteful use of the steam by these steam pumps. I incline toward the belief that there is economy in the use of electrically-driven auxiliaries, on account of the non-wasting of heat by pipe radiation, if for no other reason, because the primary objects to be attained in a power station are to generate steam with as little fuel as possible, lead it as direct as possible to the steam cylinders, where it is to do its work, and exhaust it into the vacuum as quickly, with as little pipe to radiate heat, as possible, and electrically-driven auxiliaries seem to me to accomplish this result better than any other.

Electric station equipments. The rotary converter is a machine for converting from one form of current to another, or from one pressure to another pressure of the same form of current. A machine for converting alternating to direct current, or *vice versa*, consists of a single armature revolving in one field, carrying two commutators, one direct on one side, and three-phase, two-phase, or single-phase rings on the other, being capable of taking alternating current into the phase or ring side, and delivering direct current on the other, or commutator side.

These devices are coming rapidly into use for transmission work. A number of the most modern railroads in Europe and in this country have been equipped in this way during the past year, and with excellent results. There is one road where this device has been put in under my own supervision, which has been operating very satisfactorily since the first of last July, transmitting three-phase at 5500 volts and then converting it to direct current and delivery out on the line of 600 volts. In most cases 95 to 97 per cent. efficiency may be depended upon, if the machine is reasonably large and operated at full load.

Under this head may be classified the synchronous motor driving series arc machines. One type of modern central station is utilizing its old series arc machines for supplying other circuits by driving them with synchronous motors, in case it is an alternating plant. This makes a very good combination and eliminates belts entirely from the station. The efficiency of such combined synchronous motor with arc machine is seldom more than 72 to 75 per cent.

One device, known as a rectifier, has been used quite extensively in Europe, but not in this country. It consists simply of a commutator revolved by an independent source of power, a small steam engine or motor, belted or directly connected. This commutator will take in alternating current on one side and deliver one, two, or three-phase current on the other, accomplishing the same result as a rotary converter, without the use of the field coils, or any revolving portion except commutators; and it seems to me that we are somewhat behind in not looking into it more thoroughly in this country, for it certainly can be manufactured for less money than the rotary converter. This is mentioned merely as a tendency in transmission work. The efficiency of it is about 97 per cent.

We now come to what is known as the combination generator, which wants a name, and the man who can successfully name it, and have his suggestion generally adopted, will, in a sense, become electrically immortal. It consists of a machine having two commutators and capable of generating current at two voltages. It may be direct current on each end or alternating current on one end and direct on the other; but, in either case, it is a machine deriving its power from an external source in contradistinction to a rotary converter, which revolves itself by means of the current passing through it. These machines are coming into use for railway work, telegraphy, and printing office work. They seem to be the connecting link between the alternating and direct current apparatus. A power station installed with such machines is capable of generating polyphase current and transmitting such current by means of static transformers, to a long distance at a high potential, then running through rotary converters, and delivering out on the line direct current, thus enabling us to utilize our direct current motors which are already installed. The efficiency of such a machine is from 92 to 96 per cent., dependent upon its size.

Boosters are of two kinds, the rotary and the static. The rotary booster is a machine consisting of two dynamo-electric machines, one of which is a motor which may be either alternating or direct current, or arc. This machine is used mainly at the present time for use on long distance feeders in railway and central station work. The generator end of the machine is series wound, and through it passes all the current which goes through the feeder to which it is attached. It is a low voltage machine and increases the voltage on the feeder to which it is attached a sufficient amount to enable current to be delivered at the end of a long feeder at the same pressure that is delivered at the ends of shorter feeders connected with the system. In other words, it is a device to save copper. But when it is used the line loss is increased. However, under conditions where for short periods of the day the load is heavy, it pays to do this instead of adding the requisite amount of copper. It is adopted in a number of the Edison central stations of the country at the present time, and in some railroad plants. It is largely used in stations operating storage batteries, for increasing the potential when charging. The efficiency of such a machine is from 80 to 85 per cent.

A static booster is practically a transformer and is intended to be used upon the long feeders of alternating systems. It performs the same function that the rotary booster does, by raising the pressure of the long feeder to a higher potential, so as to make the current delivered of the proper potential. It has an efficiency of 90 to 97 per cent.

The advantages of the storage battery auxiliary have been so thoroughly discussed of late, that it will be unnecessary for me to enter further into a discussion of its merits. While some engineers are not yet ready to consider its use established practice, its adoption by many of the leading direct current stations of this country should prove its usefulness.

There is one type of machine whose future has not as yet been determined, and perhaps no man can at present safely foretell its future, but there seems to be a demand for it. I refer to the multi-circuit arc dynamo. There is such a machine made to deliver a current for four circuits of about 100 lights each, and if the series arc is to survive, this type, made to deliver current for 5 to 10-100 light circuit, will be the arc machine of the future, and it will revolve at the same rate of speed as our present direct-connected incandescent or alternating machines do, because we must eliminate belts. I am speaking of large stations, and, as I say, if the series arc is to survive, it will be driven by large machines with slow rotative speeds. Such a machine will probably not have an efficiency greater than from 60 to 62 per cent., and that is what militates against it, the same as the low efficiency of the present series arc machine does.

Having thus enumerated somewhat briefly the principal factors which are working to shape the design of the future central station, I will briefly describe two types of stations which have lately been built, and seem to represent the latest practice.

1. The composite station, consisting of two or more independent steam units carrying upon the engine shaft a direct-connected generator suitable for giving light or power, and in addition, a pulley or fly-wheel carrying a belt or rope driving onto a common shaft to which the other engines similarly drive, and from which small direct-current arc machines or other old style machines derive their power. This type is admirably adapted for utilizing out of date machinery. There have been several large plants of this style installed in the last two or three years by a leading firm of engineers, and the stations, I understand, are giving excellent satisfaction. I refer particularly to the stations at Toledo and Washington, and the solutions of the particular conditions of these cases seem happy ones, because they enable the owners of the properties to utilize all of their old machinery, until such time as it may be deemed advisable to change.

2. Consists of independent engines carrying direct-connected generators. This type is admirably adapted for plants where but one kind of current is delivered; but in case two kinds are required, it becomes necessary to have a generator of each type upon each engine shaft, or have double the number of reserve units that would be required if but one kind of current were desired from the plant. In either case, the investment in plant be-

comes excessive to insure reliability. Two or more kinds of current can be obtained from such a plant by making all of the generating units alike, so far as kind of current is concerned, and driving secondary generators by means of motors running from the main generators. This means is often adopted in rebuilding old plants for driving the old series arc machines, being directly coupled to an alternating or direct current motor driven from the main 'bus bars. While the stations I mentioned are good engineering, I believe this is better engineering, that is, to eliminate belts entirely; and if we have a number of different types of machine to drive, we had better produce our energy from standard machines of the same character and size, if possible; then drive the older type of high speed machine directly connected from motors, and the efficiency of the combined plant will, I believe, be better than where the belted type is used.

3. There is one other method of construction which I will not class as accepted, but mention it as a tendency in power station design, known as the Arnold system. There have been several of the plants installed, in which the generators are carried on independent bearings, and all made available from more than one engine; but, as I do not wish to take advantage of you, I will refrain from discussing the merits or demerits of this sytem. It is claimed by its advocates to have certain advantages.*

In conclusion, we all know that our ideal central station will be designed when we have secured an electric generator capable of producing energy for universal use, and the necessary auxiliaries in the way of motors and lights to satisfactorily use this energy for all purposes when distance is taken into account. Our expectations and our hopes point toward the alternating machine, but before we can accept it as our ameliorator we must ask its advocates to produce a motor which will start and operate successfully on variable loads without seriously affecting the balance of the plant, and of producing a given amount of light with the same energy and cleanliness that is now provided by means of the direct current arc and incandescent lamp.

I, personally, lean toward the alternating system, but if we are frank with ourselves, we must admit that while the promoters of the alternating system have made very rapid strides in the last five years in the perfection of their machinery, and have overcome difficulties which five years ago seemed insurmountable, there are certain elements yet which they have not overcome, and which we hope they will overcome, and when they do we have come out of the wilderness. But the chief difficulty of the present time is in getting an alternating motor which can be used on such work as printing press work, which is exacting in the extreme; upon electric elevator work, which is one of the chief sources of revenue for central station plants, especially in large cities; and an arc lamp which will run upon practically the same energy as a direct series arc lamp. The alternating arc lamp of today has been greatly perfected, and is almost perfect so far as the quality of light is concerned, and absence of noise. It, however, has a slight deposit of ashes in the globe which requires it to be cleaned oftener than the direct current lamp, and absorbs or consumes somewhat more energy than the other type of arc lamp, and while it is to be hoped that these objections will be removed, and they probably will be, we have not yet reached the point where we can place them exactly on a par with the other type of lamps.

I believe that the connecting link between the present direct current station and the future alternating central station, lies in what I have mentioned before, in the combination generator. We can install machines today which will produce both direct current and alternating current and which will drive our present direct current motors satisfactorily, until the time comes when the alternating motor is perfected. Then, by simply taking off the commutators of the same machines, you can convert them immediately to do alternating work, without any additional expense. I believe that the central stations of the present, and for several years to come, will be designed on these lines and with combination machines.

Transportation

RAILWAY ELECTROLYSIS POPULARIZED.

[COMMUNICATED.]

VAGUE indeed are the ideas prevailing among the greater part of business men respecting the electric current. The action of this invisible agent, so dreadful in the thunderstorm, so grand and beautiful in electric lighting—reaching its culmination in the display of the aurora borealis—so powerful and obedient when used as a motive power, and so awe-inspiring when some unfortunate lineman inadvertently places his hand on one of those small, ordinary looking copper wires and is instantly stretched out a corpse; there is little need for wonder that imperfect ideas should prevail, especially when those who know most about it have much yet to learn. The electric current is now proving so useful that we see some manifestation of it continually and there appears to be no end to the uses to which it is being applied.

In its primary state it is energy in motion the same as wind is air in motion. It may be of so faint a nature as to be outside of the reach of the most sensitive instruments that have been invented. From this vanishing point it has been found to be possible to amplify and energize the current to almost any extent. To illustrate: We take a quantity of water to a suitable pressure machine and we can put energy or power into it to almost an unlimited extent; this water has not changed its form, it is the same weight and has the same familiar appearance, but a few drops would as surely kill as the electric current. We lay small, strong steel pipes through the streets and take small pipes from them, and in the factories attach them to machines of any required size and duty; the water, after the power is extracted by the machines, runs off by the waste pipe harmlessly.

It is not as easy to procure a supply of the electric current as it is to procure a supply of water. The chief source of supply at the present time is the coal pile. As there is a demand for a large amount of the electric current, we obtain it by attaching a machine called a generator to a prime mover and it readily supplies all that is needed. A small steam engine will furnish a small amount of current, and this amount increases with each increase of power.

A current of electricity flows from the generator, when actuated, the same as water flows from a pump when actuated by an engine for that purpose. But the current of electricity is of no value for power purposes unless there is power put into it. This corresponds precisely with elevating a quantity of water, which, in falling back to the earth, can be made to give up that power. To put water under pressure is the same as elevating it. So with electric current when power is put into it and it is sent forth to do work; it is then spoken of as having voltage. Thus we have currents of 1, or 2, or 500 volts pressure: this is the measure of the potential force. Low pressure currents are used in metallurgical works for depositing metals; for electric lighting, pressures of 100 or 200 volts are commonly used, and for driving street car motors a pressure of 500 volts generally prevails.

---

*The "Arnold system" is a direct connected system throughout, no belts being used. There has recently been a 5000-kilowatt plant installed under this system, 1500 kilowatts of which is now running, and a brief description of this plant will give an idea of the system. One engine is installed with a shaft terminating in a flange. Sufficient room is left for two generators, and then another engine is installed, having a flange on each end of its shaft to which to connect generators. Between the two engines are placed two generators having their shafts in line with the engine shaft. These generators are mounted on hollow shafts or quills carried in their own bearings. Beginning at the end of one engine shaft and extending through the quills, not touching them, to the other engine shaft, is an auxiliary shaft carried in two bearings near its center. With this auxiliary shaft, which is independent of either engine or generator shaft, either one or both the generators between the engines can be connected to either engine when in motion or standing still. This interior shaft does not revolve under normal conditions, but lies idle to be taken up in an emergency, and under normal conditions you drive directly-connected. Machines, generators, and engines may be added in line at any time, and with a new engine four generators will be available from each large or interior engine. By making the end engine extra strong, so that it will carry 100 per cent. overload, which can very easily be done with slight increased cost, in case the large engine lets down, two generators may be run at full capacity from the small engine until the large engine is again ready for work. This requires much less investment in plant than would otherwise be necessary to meet this emergency with independent units of power.—ED.

These currents are sent forth from the generator on a copper wire. To conserve this energy until it reaches the place where it is to be used, and so earn money, it must not be permitted to leave the wire, which, in railway work, is carefully insulated, or electrically isolated from the earth, because, if by any means it could reach the ground the voltage would instantly be absorbed by the earth and the power would vanish the same as if the faucet of the water power pipe or hydraulic main were opened wide. When the power has been entirely used the electric current has been rendered practically inert. The rate of flow of the electric current sent along the wires is measured by amperes, the same as we measure water by the miners inch, and amperes of electric current are as capable of measurement (when passing through an instrument called an ampere meter or ammeter) as time can be measured by a clock. Thus we have a small current of one ampere or more used in metallurgy or telegraphy, or of ten amperes for arc electric lighting, while street cars generally require an average current of fifty amperes. The amperes represent the current itself, and the volts show the strength or electric pressure exerted on the current. It is the amperes that do the work and they represent one factor of the cost of electrical energy; the volts represent the remaining factor.

But there is a very singular thing connected with the supply of the electricity, and this may be illustrated by returning to our hydraulic main. Imagine, if you can, that this great city is located in the desert of Sahara, or in some such place where water is remarkably scarce, in which event the company owning the electric power station would see to it that every drop of water used for power in the various machines, shops, elevators, etc., was returned to the works to be used again *ad infinitum*. The company could not afford to pump the water 10,000 feet from the bowels of the earth whenever it needed water, for it might thus take three times as much power to pump the water as to put power into the water when finally obtained. It is just so with the electric railway companies. The duly energized current is carefully conducted along the railroad line and from time to time the feeder is tapped to the trolley wire; thence it rushes to the motors driving the wheels. The volts put out by the generator are all consumed by the time the amperes have been forced back to the power house, and this consumption of voltage occurs in three ways: (1) in the trolley lines and feeders; (2) in the motors, (3) in the track and earth return, but as the track is generally defective as a conductor of electricity, the amperes are absorbed by the earth in such a manner that before they have become spent they have time to work great mischief amongst water pipes, gas pipes, and the structural iron of great buildings. These effects become more apparent when there is an insufficient path for the spent current to return to the power house. The current possesses an irresistible tendency to return to the power house from any point where it may be liberated from the servitude of driving motors or lights, but it is a fact that very little pains are frequently taken to insure its safe or proper return.

Many tramway people do not see these things in this way and they go on sacrificing their own well being and pumping the cities full of injurious and dangerous currents. The railroad authorities are shown clearly to be sacrificing money in not caring as much for the spent current as for the live current.

It is a well known fact that for the installation of machinery to operate any electric road, steam power must be applied equal to a pull for each horse-power of 30 pounds per ton on a level grade. In locomotive engineering a pull of eight pounds per ton on a level grade is the proper allowance for one horse-power, showing that electric railway engineering is nearly four times more expensive than it ought to be. Moreover, the tracks on which electric cars are operated are superior in every respect to the steam roads.

The rails of electric roads can be made into fine conduits for the safe return of the subtle current, which will never leave a good channel, path, or conductor for a poor one. The earth is a bad conductor of current; iron is a good conductor; copper is better. From the power house the current is carried on large wires, the greater the number of amperes the greater the capacity or area required in the wire; the voltage does not require to be considered, but when the voltage increases, the insulation has to be made more perfect and secure. After attaining a distance of say two miles from the power house, wire of less diameter is used as about one-third of the current has generally been used on reaching this distance. After reaching the fourth mile the area of the feeder is again much reduced, and near the end of the route the trolley wire alone carries the last of the current. Ordinarily, the total area of copper wires leaving the power house on any one route is less than a rod of copper one inch in diameter. For a return path the area should be larger on the same principle that we make the exhaust pipe of the steam engine larger than the feed pipe. Iron is not as good a conductor as copper, the ratio being nearly 7 to 1. The weight of rails used on the electric railroads is generally over 70 pounds per yard; such a rail has an area of seven square inches, which is fully equivalent, as a conductor of electricity, to a square inch of copper. The route has, say, four rails, hence it affords a pathway for current four times as large as that of the live wires from the power house at their greatest cross section. But, as the rails are in lengths of 30 feet and are joined together by bolted fish plates, this break in continuity is fatal to the passage of the current and must be bridged over. This is done by "bonding" or attaching copper wires, joining one rail electrically to another. The copper wire thus joining the rails together should be larger in area than the cross section of the feeders at that point.

Bonding has been found to be a most difficult problem, and on many lines the bonding is almost useless for many reasons. Then came the cast iron and welded joints which were loudly proclaimed to afford a perfect solution of the difficulty; but now, after incurring very great expense for these joints, they are found to be also defective and water pipes have still been greatly damaged in their neighborhood. The melted metal coming in contact with the cold metal acts as a mold, causing a skin to form upon the coating, offering great resistance to the passage of the current which wanders off seeking an easier path. It thus finds a water or gas pipe within a short distance and travels along it, leaving its mark at the lead joints, or elsewhere, and at times causing deposits inside the pipe. The actual damage done to iron pipes and structural iron may be described as a species of rottenness, the familiar metallic features becoming quite changed so that they may be easily cut away with a pocket knife.

The failure of the cast and welded joints to carry current in a satisfactory manner is much to be deplored, because they have given a great amount of solidity to the track and also entirely obviated the movement of the joints in a vertical plane. They have also confirmed what engineers have well known, viz.: that proper construction of the track would entirely obviate the necessity of making provision for expansion and contraction. Electrical engineers (so-called) are behind the age in still providing for expansion and contraction in their bonds when none is required. The present practice of casting and welding joints might easily be perfected so as to remedy the present defect. It simply requires for each joint five cents worth of copper in one or more pieces having together the same area as the feed wire carrying the live current from the power house, to be fixed to the steel rail ends in a workmanlike manner so that the area of the surface of the steel in contact shall be seven times the area of the copper. Then proceed with the casting or welding of the joint so that no copper shall be visible. This will furnish a path for the current superior to any in existence.

According to present appearances the greater part of the street railroad companies are doing practically nothing to remedy the evil which now exists in greater or less degree in every city in the union. The water and gas companies are, therefore, showing signs of increasing uneasiness, and from their standpoint it is not

Continued on page 46.)

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of
Electricity and Transmission of Power.

Official Organ of the Pacific Coast Electric Transmission Association.

Subscription invariably payable in advance. Terms—Domestic, One Dollar per Year; Foreign, Two Dollars per Year. The trade supplied by the San Francisco News Company. Advertising rates furnished on application.

GEO. P. LOW, : : : Editor and Proprietor

PUBLICATION OFFICE:
320 CALIFORNIA STREET,
ROOM 14.

Address all communications to
Editorial rooms, 427 TENTH AVE.
Telephone, "Steiner 627."

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME VII MARCH, 1899 NUMBER 3

EDITORIAL.

THE LIMITS OF ELECTRIC POWER TRANSMISSION.

It is often profitable to revert to the earlier days of an industry and look over, with a view of comparison with subsequent developments, the reasonings then advanced along what may be termed prophetic lines. Such an article is that of Mr. Alton D. Adams, written in 1895[*] on "The Limits of Electric Power Transmission," in an opening paragraph of which appears an expression of opinion that, in the light of developments of the present, is eminently sound. "While long distance transmissions may form attractive experiments," states Mr. Adams, "it must be demonstrated that it is possible to thus deliver power more cheaply than it can be generated at the point of use, before they can be common. The cost of transmitted power increases with the distance, and it is obvious that, assuming absolutely free power at the start, a distance may be chosen great enough to consume its entire value in the cost of transmission. To make, then, the transmissions of power commercially practical, it is necessary that the cost of transmission be less than the difference between the value of the power at the starting point and its value at the point of delivery."

Before analyzing that which constitutes the uncertain element of cost of transmissions, it may be stated that long distance power transmissions are common in California, because fuel and climatic conditions are propitious, and they are common in certain other districts where high priced fuel and reliable water powers combine to make favorable conditions, but it can not be said that Pacific Coast transmissions, depending upon uncertain water supplies, as many of them do, have yet demonstrated their ability to deliver power at their markets at a cheaper rate than it can be produced there by steam. That such transmissions maintain competition with steam is undeniable, and that they make serious inroads into the business of the older steam plants is also true, but nevertheless the steam plants keep on paying dividends, while the transmission plants generally find their main solace in statements to the stockholders or prospective bond buyers to the effect that the earnings have gone into extensions, improvements or betterments.

Let it not be adjudged from this that long distance transmission in California is a commercial failure, for such would be far from the fact as there are some such plants that are in superb financial condition and are investments much to be desired. But there are others in operation where the investor has been the victim of the perpetrator, rather than being benefitted by the promoter. The technical success of electric power transmissions is now well established; their commercial success is indeterminate by any other rule than that of a rigorous, thorough and conscientious analysis of all local conditions pertaining to each and every feature of the installation. In brief, every transmission project soliciting financial aid may well be considered as spurious until its promoters shall do the equivalent of issuing a prospectus challenging an investigation of the reliability of its water rights, of the value of the market to be supplied, of the technical feasibility of the points involved, of the total cost of delivery, and, finally, of the cost of production of the steam or other power with which it may come into competition.

A promoter, or a perpetrator, if he be such, who has a transmission project to float, will, figuratively speaking, take the prospective investor to the power house of the steam plant where seething furnaces devour tons of coal each day, and will there point out to him that the firemen are shoveling hard dollars under the boiler, or mayhap, that the quantity of dollars to go under the boilers is so great that it can not be handled by perspiring firemen, so ponderous mechanical devices known as stokers have to be used. The investor nods assent. Then a trip to the mountains is carried out at a propitious season and the prospective investor stands in awe at the thundering grandeur of the mountain stream, roaring down the canyon in torrential flood. "These are Nature's forces," shouts the promoter, "forces like those which cause the earth and tides and the sun and moon to revolve, and by harnessing them we can run every wheel in the country!" Again the prospective investor nods assent, and within the day he has become an enthusiastic convert.

Then follows the period of construction, the money is ready and all progresses smoothly; the inauguration of the enterprise is blared to all quarters as the opening of a new era and congratulations and champagne mingle merrily.

Chapter three opens with a list of "unforseen" emergencies that is appalling in its length: counter movements of rival companies, extension expenses for distribution purposes, plant enlargement for different character of service than originally contemplated, alterations in the engineering designs of the original plans, washouts and breaks in flumes and ditches, drouth and partial or total failure of water supply, auxiliary steam plants and additional generators, transformers and station equipment for the same, current bought from outside sources for emergencies, and, finally, the securing of a big contract containing a provision that steam must be kept up at all hours on an auxiliary plant in order that continuity of service may be better assured. Then as to cases in which water rights have not been fully acquired: an instance wherein a water company charged six dollars per horse-power per month for the right to use water flowing past a power house—$1800 in gold per month for 300 horse-power in water simply diverted and returned to the ditch again—is not without precedent. It is in such preventable exigencies as these that the commercial limitations to electric power transmissions are largely to be found.

---

[*] *The Engineering Magazine*, Vol. X, No. 2, page 269.

Chapter four is yet to be written, but the sequel to the story may easily be foreseen. While electric power transmissions have given the lie to the revered adage, "the mill will never run with the water that has passed," still they cannot conjure with magic and they must face the inevitable fact that there is, after all, no difference in whether money is consumed in coal burned under steam boilers, or whether it is consumed in interest and fixed charges, so long as the amount in each case remains the same. And in this very point of the amount of money consumed in each case rests the solution to the problem of the limitations of electric power transmission, but to find the solution, analyses must be made of local or specific conditions—not prevailing generalities.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

THE FUTURE OF NON-LUMINOUS GAS.

Dr. H. Bunte, in his "Observations upon Water Gas,"* points out that since by the Welsbach incandescent gas light, non-luminous coal gas has become a peculiar light dispenser, and since the same result can be attained with non-illuminating water gas, the economic adoption of the water gas process betokens an advance which the illuminating gas industry has every cause to keep before its eyes. "Not a hostile competitor," continues Dr. Bunte, "but as a confederate, we take the liberty of addressing this rival who makes it possible for the gas industry, even though father in the future, to hold in its right hand light, heat, and power. And indeed, we ask ourselves the question, Will our coal gas now, as ten years ago, exclusively, or even in great part, be employed as illuminating gas? Have the illuminating constituents of coal gas, which we measure with the photometer, still the same value as ten years ago before the Welsbach burner made its entry into the domain of gas illumination? We must answer this question in the negative. Everywhere where the Bunsen burner has appeared, whether it be as a gas light or for cooking and heating, the illuminating constituents are purposely destroyed before use converts them into a non-luminous heating flame. The more extensive incandescent gas lighting becomes, and the more extensive becomes the employment of gas in heating and cooking, the more do the illuminating constituents of coal gas diminish in value."

When Dr. Bunte asks whether the illuminating constituents of coal gas still have the same value as prior to the entry of the Welsbach into the domain of gas illumination, he might with equal propriety have included the illumination constituents of water gas. The development of the Welsbach seems, from this line of reasoning, to be destined to make nugatory the present all but universal practice of enriching water gas by the introduction of the hydrocarbons derived from oil. What then, it may be asked, stands in the way of the eventual use of non-luminous gas (which is but another name for fuel gas) for the universal use of gaseous light, heat and power? This at least is the opinion of Mr. James Stelfox in his inaugural address as president of the Incorporated Gas Institute at Belfast, in June, 1898.

This address, by the way, gives serious consideration to the claim that it was found at the Vienna General Hospital that, for a given amount of light in Welsbach mantles, uncarbureted water gas, made on the Strache method, developed only about one-third of the amount of heat produced by a similar burner consuming coal gas, and the production of carbonic acid was only one-half; while comparing it with the products of coal gas consumed in ordinary burners, the heat produced was only one-eleventh, and the production of carbonic acid less than one-seventh.

BREAKING DOWN THE BARRIERS OF CONSERVATISM.

The over-conservatism with which the mining interests have long looked upon the introduction of new appliances, and particularly electrical equipments, into their business methods has perhaps done more to retard the use of electrical devices in that direction than has any other single element; but in the long run merit will tell and in every industry there are always minds which are free from prejudice and which stand ready to adopt whatever there is of the new that improves upon the old. Through the spirit of progression which pervades this class of the mining industry, electricity owes the high attainment it has reached in the various channels of mining development. The field has long been an inviting, though not a yielding one, and it can but be gratifying to note the favor with which electrical appliances are now being held in practically every branch of mining work.

Witness, for instance, an editorial statement in the current number of *The Engineering and Mining Journal*, which says that for many years it has been acknowledged that electricity can furnish the power for every line of mining work. At first it began with signaling, then blasting, and there was a pause. The idea of using electricity as a power for heavy work seemed absurd when exemplified to the ordinary observer in a current carried by a little copper wire. It was in Colorado that the first application on a large working scale was applied, and the combination of water power and electricity was put in practice. The installation at the Virginius mine is a familiar example. "Now we find," continues our contemporary, "electricity employed for hoisting, pumping,

---

**The Gas World*, January 14, 1899, page 54.

drilling, and all the operations of mining. There was a hitch about the drill, the gadder, and the coal cutter, but it seems to have been overcome; so that it is now safe to say that there is nothing done in mining which can be done by steam power directly, or indirectly by compressed air, or wire rope transmission, which can not be done equally well by electricity—the selection depending upon difference in first cost, running expense and maintenance. The strange thing is that in some cases electricity has helped its competitors, as, for example, in the combination with air compressors."

THE MOUNT WHITNEY TRANSMISSION.

Through the application of electric power the problem of irrigation in California has been greatly simplified. Up to the present time pumping stations have required steam or gasoline engine plants which often necessitated the transportation of fuel over considerable distances, making the operation quite costly. The utilization of the electric motor for operating pumps in supplying water from artesian wells will eliminate the use of these plants wherever electric service can be more cheaply rendered.

One of the largest and most important electric power plants of this description has recently been contracted for by the Mount Whitney Power Company, of Visalia, Cal., with the Westinghouse Electric and Manufacturing Company. The project as it is to be carried out is an extensive one, involving three 600 horse-power alternating current generators direct-connected to water wheels, two direct current generators for exciting the fields of these alternators, and four 500 horse-power raising transformers, together with all other necessary auxiliary apparatus.

From the central station, where the above machinery will be installed, the current is to be transmitted to five sub-stations conveniently located with respect to the artesian wells. In these sub-stations are to be placed step-down transformers and switchboards for receiving the current from the transmission circuits and delivering it at a lower potential suitable for operating the various motors located at each of the sub-stations. The motors are to be connected to the pumps for drawing water from the artesian wells, thus keeping up the irrigation of the land as may be required. The contract calls for eighteen Westinghouse motors ranging in size from ½ horse-power to 30 horse-power, and the sub-stations are located at Lemoncobe, Lindsay, Porterville, Tulare and Visalia. The Mount Whitney Power Company proposes also to distribute a portion of the current from the central station to the city of Visalia for light and power purposes. Work on the entire system is now being actively prosecuted.

CASSIER'S ELECTRIC RAILWAY NUMBER.

There have probably never been published two more remarkable numbers of any periodical than the marine number and the Niagara power number of *Cassier's Magazine*, which appeared in 1897 and 1895 respectively, each containing several hundred pages of text and illustrations, with all articles prepared by men of the highest standing in their several professions and with illustrations of the first order of artistic merit.

The highly gratifying success attending the publication of these two remarkable specimens of engineering literature has prompted the Cassier Magazine Company to commence the preparation of another special mumber, to be devoted to electric transportation, and will be known as the electric railway number. As in the other two cases, the contributors which have been secured for this number are men of the highest professional standing, and what they have written is of enduring merit. There will be about fifteen articles relating to all branches of electric railway construction, maintenance and operation, and all together will constitute a volume which should be in every electrical and mechanical engineer's library.

RAILWAY ELECTROLYSIS POPULARIZED.

(*Continued from page 43.*)

difficult to foretell that, unless correctives are applied, the time is surely coming when many of the street car systems now enjoyed will be tied up by injunctions. This would be to the embarrassment of thousands who have built homes in the suburbs, as well as the ruin of those who have placed their funds in the securities of those companies.

In Dayton, Ohio, the city has a just claim against the Peoples' Railroad Company for $100,000 for destruction of water and gas pipes on a partial investigation; and the mischief still goes on. The railroad companies of Brooklyn, N. Y., are now being sued in the courts for damages laid at $3,000,000, and two hundred suits are likely to be added, with additional claims of $17,000,000.

Municipal boards are composed of business men chosen because of their business qualifications. Very few have had time or inclination to study the subject under consideration, but there is a way of looking at and dealing with the matter which may perhaps commend itself to such boards and which requires no technical knowlege to understand. The proposition is to enact an ordinance which shall require every electric railroad company doing business within the city to furnish daily a statement under the official seal of the company of the amperes of current sent out over each and every route owned by the company, the readings to be taken from recording ammeters placed in the outgoing feeders at the switchboard of the power house and read each hour of the day or night during which the engines may be operated. The railroad company shall also cause wires to be attached to each rail of said route or routes when it shall reach its nearest or most suitable point near the power house, as well as to ground plates and each water or gas main adjacent, and cause said wires to be connected to similar recording ammeters in such manner as to measure hourly the number of amperes of electric current returning to said power house. Thus will be obtained a record at each hour of the day of the outgoing and returning currents, these records to be duly placed on file. If, from a consideration of the record, it should appear that there is no current returned by the rails or any rail, or ground plates, or if the conductivity of any rail or ground plates did not reach a specified percentage, then the railroad company should be directed to provide a remedy within a certain specified time, subject to such extension as may be considered proper.

Electric lighting companies should also be required to furnish daily statements regarding the outgoing and returning currents, and instruments used in measuring the currents and also the wire connecting the rails with the instruments, should be open for inspection at any time by any duly authorized city official.

Mr. W. F. C. Hasson, of the late engineering firm of Hasson & Hunt, states that he is winding up its and his own business affairs preparatory to moving to the Hawaiian Islands, where he proposes to locate.

Gas

ACETYLENE.*

BY PROF. VIVIAN B. LEWES, F. I. C., F. C. S.

IV.

A CONSIDERABLE amount of vagueness exists as to what is meant by the illuminating value of a gas, and the only assumption which can be arrived at is that it is the highest illuminating effect which can be produced from the gas without the aid of regeneration or artificial air supply other than that created by the flame itself. The proper combustion of any hydrocarbon gas, however rich, can be effected by supplying the flame with exactly the amount of air necessary to prevent smoking, and it is under these conditions that the highest illuminating effect possible with the particular burner is obtained. With flat flames the ratio between the air supplied and the gas consumed is governed by two factors: (1) the thickness of the flame; (2) the pressure under which the gas issues from the burner. When a gas issues from a burner under pressure, the uprush of the escaping gas mechanically draws in air, so that when consuming a poor coal gas in a flat flame the pressure has to be kept down, or too much air would be dragged in which would consume the hydrocarbons too rapidly, and so seriously effect the amount of light emitted, whilst, as the gas increases in illuminating value, more and more air is required for proper combustion, and this can be obtained by increasing the pressure at the burner.

BURNERS.

Experience has shown that with ordinary sized, flat flame burners seven-tenths of an inch in pressure gives practically the best results with coal gas of the quality supplied in London, and up to a certain limit the same flat flame burner can be used for richer gases by increasing the pressure. When this limit is reached a thinner sheet of flame has to be employed; *i. e.*, a smaller burner used, low initial pressure resorted to, and then, by increasing pressure this can be made to consume gases of increasing value, until the pressure reaches a point at which the flame becomes distorted, when a still smaller burner has to be taken. By such means as these even acetylene, with its enormously high illuminating value, can be satisfactorily consumed, whilst by thickening the flame and reducing the pressure to the point at which the uprush almost ceases to cause a mingling of air with the flame and leaves the supplying of the oxygen to diffusion, even a poor gas can be made to develop its illuminating power.

On consuming acetylene from a No. 000 union jet burner, at all ordinary pressures a smoky flame is obtained, but on increasing the pressure to four inches, a magnificent flame results, free from smoke, and developing an illuminating value of 240 candles per five cubic feet of gas consumed. Slightly higher values have been obtained, but 240 may be taken as the average value under these conditions. This figure is the one quoted by most manufacturers of acetylene apparatus, who argue from it that acetylene is 15 times as valuable in illuminating power, volume for volume, as London coal gas. Such a comparison is, however, absolutely misleading, as in contrasting the value of acetylene with coal gas, one must bear in mind that the illuminating power of London gas is determined by consuming it at the rate of five cubic feet per hour in the London argand, whilst in practice any power from 8 to 90 candles can be obtained from this volume, according to the form of burner in which it is consumed. Although small flat flame burners only emit from one to two candles per cubic foot of gas consumed, good incandescent mantles will yield about 18 candles per cubic foot, and certainly 17 on the average, and as incandescent gas lighting is rapidly displacing other methods of burning gas, and as this tendency will be enormously increased when the lapsing of the Welsbach monopoly reduces the price of the mantles to the figure now charged in Germany, it is evident that no calculation is fair that does not include this as a factor. Moreover, a very short experience soon shows that burners consuming one cubic foot of acetylene per hour are the largest that can be practically used for domestic purposes, and taking such burners all round, 32 candles per cubic foot is a fair average of the light developed by them, although out of a big batch of burners you occasionally find a few which will go as high as 36 or even 40 candles per cubic foot. As the consumption of acetylene is regulated by exactly the same factors as act in the case of coal gas, it is evident that the smaller the burner and consumption, the lower will be the candle power per cubic foot of the acetylene. In practice, with a one-half cubic foot burner, 24 candles per cubic foot is a good result.

The only fair way to contrast the light obtainable from coal gas and acetylene is to take the incandescent burner on the one hand and the one cubic foot flat flame on the other. Then it is seen that instead of having 15 times the value of the coal gas as an illuminant, it has only about twice its power. The acetylene burner, however, has one advantage over the mantle, and that is that you can more or less regulate the light to the amount you require.

HEATING AND VITIATING EFFECTS.

When acetylene is burned in air, under such conditions as to complete its combustion, it is converted into carbon dioxide and water vapor, the same compounds as are produced by all combustible hydro-carbons:

$$2C_2H_2+5O_2=4CO_2+2H_2O.$$

One cubic foot of acetylene requires 2½ cubic feet of oxygen. The researches of Dr. Gréhant have shown that when burning with a smokeless flame no carbon monoxide can be detected in the products emitted by its combustion, and its sanitary position will, therefore, be defined by the amount of oxygen abstracted from the air and of carbon dioxide produced, as compared with other illuminants.

Taking the average sized room, which would be well lighted by an illumination equal to 64 standard candles, we find that this amount of light, from various illuminants, would yield the following results:

Illuminant.	Oxygen Removed from Air. Cubic Feet.	Products of Water Vapor. Cubic Feet.	Combustion Carbon Dioxide. Cubic Feet.
Sperm Candles	38.5	26.2	43.6
Paraffine Oil	24.9	14.0	39.8
London Gas—Batswing	26.1	29.4	19.2
Argand	23.0	25.6	17.0
Regenerative.	10.6	8.3	5.2
Incandescent.	3.1	4.6	1.8
Acetylene	5.0	2.0	4.0

So that, light for light, acetylene fouls the air less than any of the ordinary illuminants, with the exception of the incandescent gas burner.

In comparing the heating effect of various illuminants on the air of a room, it is necessary to determine the calorific value of the combustion of a cubic foot of the illuminating gas employed, and it is manifest, from theoretical considerations, that a highly endothermic compound like acetylene must have a far higher heating power than ordinary coal gas. The mean of a number of experiments made in Junker's calorimeter gave as the thermal value of the ordinary London gas supply 158 calories, whilst under the same conditions acetylene yielded 320. The theoretical amount of heat emitted by the combustion of a cubic foot of acetylene is 349.08 calories, but this would only be given by the absolutely pure and dried gas, and the experimental number determined in the calorimeter represents more truly the heating power of the moist gas under ordinarily existing conditions.

Taking now the case in which a room is lit up with a power equal to 64 candles, we find that if we call the heating effect produced by an incandescent mantle giving this amount of illumination 100, then:

Ratio of heat emitted to yield a light of 64 candles:

Incandescent mantle	100
Acetylene	115
London Argands	571
Flat flame burners	914

---

*Abstract of the last of a series of four Cantor lectures delivered to the Society of Arts, London.

So that, for all practical purposes, the heating effect on the air by acetylene illumination is the same as with mantles.

ACETYLENE VERSUS COAL GAS.

When one comes to compare the cost of acetylene and coal gas, one is again struck with admiration at the statements made by the advocates of acetylene as a rival to the well established coal gas industry. At the present time the wholesale price of carbide is £20 a ton, but I believe that, to fill large cash orders, it can be obtained at £16, at Foyers, which would mean at least £20 a ton at the works where it is to be decomposed and the gas distributed. The decomposition of carbide is not only a costly operation, but at least 10 per cent. would have to be added to the price of the carbide for handling, water, repairs, interest on plant, purification, etc., and this would bring the price of the acetylene to £2 per 1000 cubic feet in the holder. Coal gas in the holder, when made on the scale common in our big cities, costs about 1s. 2d. per 1000 cubic feet, and about 100 per cent. has to be added to this to cover charges of distribution and profit. The power of doing this is dependent on the amount of gas sold, and whilst the South Metropolitan can make a fair profit on gas at 2s. 3d. a thousand, there are many small country works that cannot pay a dividend with gas at three times the price. With acetylene the smallness of the output would necessitate a heavy charge over cost price, and I should be surprised to find an installation of acetylene, even in a fair sized town, paying its way with a less charge than £3 per 1000 cubic feet. Looked at from this point of view, it is at once manifest how absurd it is to talk of acetylene as a possible rival of coal gas, and the sooner this is realized the better will it be for the future of this brilliant illuminant.

Abroad, where coal gas is dear, it is possible, by taking the price of acetylene in the holder and comparing it with distributed coal gas to make acetylene out to be, light for light, as cheap as the latter when consumed in a flat flame burner, but even this method of calculation breaks down before the high light emissivity of the incandescent mantle. It is in those districts where no coal gas exists that the true field for acetylene is to be found, and here its ease of generation and the beauty of its light make it a pleasant companion after the greasy dimness of the candle or the smell of the oil lamp.

SMOKING.

The cause of smoking is to be found quite as much in the generator as in the nipple, and over-heating during generation is undoubtedly a prime factor in this worrying phenomenon. If smoke or tar vapor be examined under a high microscopic power, it is seen that it consists of minute vesicles or bubbles, in a most marvelously active condition of movement, and fulfilling in a most perfect manner the conception one forms of molecular motion. Ever bombarding each other, but never colliding, these small vesicles, filled with gaseous matter, continue their career, until some mechanical action bursts them and deposits the minute trace of liquid which formed the skin of the microscopic balloon. It is for this reason that the most successful forms of washer for extracting tar during the manufacture of gas consist of fine jets, or orifices, through which the gas passes at considerable velocity and comes in contact with a baffle which breaks up the vesicles, and any one with experience in carbureted water gas making knows the trouble that arises from filiform growths of carbon, when, owing to an insufficient temperature in the cracking and superheating chambers, the carbureted gas contains vapors instead of permanent gaseous products.

When acetylene has been made in a generator at an undue temperature, it carries with it benzine vapor, which, as it commences to condense, assumes this vesicular form, and on coming to the extremely minute holes which form the apertures of the burner, the mechanical scrubbing which it encounters causes the breaking up of the vesicles, and the decomposition of the benzine and the other hydrocarbons held in suspension by benzine which soak into the steatite and carbonize. The presence of finely divided carbon has a great effect in determining the decomposition of the acetylene itself, so that a rapid growth of carbon takes place at the burner, and no ordinary clearing of the deposited carbon from the exterior will ever make the nipple fit for constant use again, as the catalytic action of the carbon deposited in the pores of the steatite, which cannot be got rid of, causes the deposition of a fresh supply of carbon; whilst when the benzine vapor gets past the nipple and burns, as it requires three times as much air as acetylene, it often starts smoking of the flame from this cause. The impurities in acetylene, other than vapors, also play a certain part in the choking of the burner, as if there be much phosphureted hydrogen in the gas, a small quantity of phosphoric acid is apt to be deposited in the burner nipple and helps to distort the aperture, and silica from siliciureted hydrogen has the same effect.

It will be found, with experience, that the smoking in a burner will be overcome quite as much by attention to the temperature in the generator as to the burner itself; and where a generator which gives over-heating is in use, a well arranged scrubbing apparatus that would get rid of the benzine from the gas would be found a distinct advantage in stopping burner troubles, whilst when proper purification is introduced the burner trouble will be found to have been practically solved.

WELSBACHS.

The incandescent mantle has made such a revolution in coal gas lighting that it is not surprising that attempts should have been made to adapt acetylene for this purpose. The first thing which had to be done, when taking steps in this direction, was to construct an atmospheric burner which would satisfactorily consume the gas. One would expect that acetylene, when consumed in an atmospheric burner, would give an excessively hot flame, not only on account of its composition, but also on account of its endothermic character. Le Chatelier calculates that the temperature of a non-luminous acetylene flame will range from 2100° to 2420° C.; the temperature, of course, varying with the ratio of acetylene to air. In order to make a Bunsen burner for acetylene, the tube has to be extremely narrow, and it is even then found to be very liable to flash back, whilst it needs a high pressure in order to bring about satisfactory combustion of the gas with an absolutely non-luminous flame. One of the chief difficulties which has to be overcome is due to the range over which mixtures of air and acetylene are explosive. This, as we have seen, lies between the limits of three per cent. and 82 per cent. of acetylene; and it must also be remembered that the velocity of the explosion of a mixture of acetylene and air is greater than that of a mixture of air and coal gas. The propagation of the explosive wave down the burner tube cannot be satisfactorily stopped by the ordinary device of using wire gauze, on account of the low igniting point of acetylene and air mixtures; whilst if high pressures are used, so that the rate of flow shall be greater than the velocity of propagation downwards, more air is sucked in by the uprush of the gas, and the velocity of the explosion is again increased. The best results have been obtained by taking a Bunsen burner in which a constriction in the air tube creates a high velocity at that point, which, on the principle of the Smithells flame separator, prevents the propagation downwards just at that point.

Le Chatelier has shown that the rate of propagation of an explosive mixture of air and acetylene depends upon the diameter of the tube through which the wave is being propagated, and has shown that in a tube of 0.02 inch, or 0.05 mm., in diameter, you have the propagation of the explosive wave ceasing.

These investigations have been used as a basis upon which to construct acetylene burners for heating purposes, and burners have been made by the Allgemeine Carbid und Acetylengas Company, of Berlin, in which, by means of constricted tubes, satisfactory consumption is insured. It is found that the diameter of the tube at the constriction must be in a definite proportion to the particular mixture of air and acetylene consumed, as the more air employed the greater must be the constriction in the strangulated portion of the tube. Such burners have a flame which is very valuable for heating purposes, and which gives a very intense temperature. The same company has also used these burners with incandescent mantles, of somewhat different shape and composition to those ordinarily employed, and states that the photometric result is 30 to 40 per cent. higher than that obtained by the combustion of pure acetylene alone. I have lately been experimenting with an acetylene Bunsen, and get much higher results than these; as with a Welsbach No. 2 mantle I have obtained as much as 90 candles per cubic foot of acetylene consumed. As far as I have gone, the mantle appears to be hardened and strengthened by the intense heat to which it is subjected; but it yet remains to be seen how the life of the mantle is affected by the intense temperature of the flame. Acetylene atmospheric burners are now also employed for heating, cooking and metallurgical operations on a small scale, and with a reduction in the price of the gas, these uses for it will undoubtedly open up a wide field of utility.

PHOTOGRAPHY AND PHOTOMETRY.

The value of acetylene in photographic work is now universally recognized, and Mr. W. H. Walmsey has determined its relative value, as compared with the ordinary sources of light, by determining the time needed to fully expose carefully prepared plates, with the following results: Direct sunlight, one second; acetylene, one cubic foot burner, three seconds; diffused daylight reflected from mirror, 12 seconds; incandescent mantle, 24 seconds; coal gas, oil gas, oil lamp, 240 seconds.

It is also being used to a certain extent for projection work; but it is not so well suited for this, as in common with multiple wick oil lamps and incandescent mantles the flame offers too large a surface of illumination. M. Molteni has attempted to determine the projection value of various illuminants by a photometric process, in the following way: The measurements were made with an ordinary lantern, the stage of which carried an opaque card in which was cut an aperture 0.7 cubic meter square, and the distance of the lantern from the screen was such that each side of the square on the screen measured one meter. The screen was replaced by a disk of paper, the opposite side being illuminated by a standard lamp burning 42 grammes of oil per hour. The distance of this lamp was varied, in order that equality of illumination might be obtained on the screen, and the photometric values of the lights were determined from the distance of this lamp.

Multiple wick lamp	1
Incandescent gas, No. 2 burner (no reflector)	1
Acetylene, 1 burner (no reflector)	1.06
" 2 " "	1.70
" 3 " "	3.20
" 4 " "	4.10
" 5 " "	4.50
Limelight, alcohol and oxygen	5.80
" oxhydrogen	16.60
" etho-oxygen	18.50
Electric incandescent, 32 candle-power	0.68
" " 50 " vertical	0.93
" " 50 " E horizontal	0.93
" " focus 100 "	3.82
" " E arc lamp 7 amperes	39.03
" " " 10 "	75.61
" " " 12 "	86.50
" " " 15 "	117.61
" " " 20 "	160.80

TRANSMISSION OF POWER.

Carbide will probably some day become an important factor in the transmission of power, as a cubic foot of solid carbide weighs 62.26 kilos., or 137 pounds, and if of commercial purity would yield 685 cubic feet of acetylene, having a thermal value of nearly 232,215 calories. In practice, however, the weight of carbide which can be got into a cubic foot space is dependent on the size to which the material is broken; and with the ordinary commercial carbide, a fair average would be 80 pounds per cubic foot, yielding 400 cubic feet of acetylene gas, with a thermal value of 139,600 calories. It is at once manifest that solid carbide is as economical a method of transporting acetylene as if liquid acetylene itself were employed, as the liquid would only yield about 400 times its own volume of gas; and the carbide has the advantage of being practically safe in transit. There are several people at present working on the utilization of acetylene for gas motors; but there are many difficulties to be overcome before this is successfully accomplished, as the deposition of carbon, when the air supply is insufficient, and the violence of the explosion, are troublesome factors to be dealt with.

The trouble of completely consuming acetylene without smoking, in the early days of its inception, caused Dickerson and Suckert to attempt the combustion of acetylene diluted with air, and in 1894 it was in this way that the gas was consumed. But not only did the cooling action of the nitrogen lead to a considerable decrease in the illuminating power of the acetylene so diluted, but, as will have been seen from the experiments of Gerdes and others, a very serious risk was incurred, it becoming merely a question of the breadth of the delivery tubes and the rate of flow of the gas whether an explosive wave was propagated back to the mixing machine or not. It was on account of the danger of this that this process of burning it was abandoned in America. The idea has, however, cropped up from time to time since, and it has been used in both France and Holland to a certain extent, on a practical scale; and even at the present time an attempt is being made in Manchester to introduce a process by which acetylene can be so diluted with air as to burn in an ordinary Bray burner.

ENRICHING.

It was about 1895 that Mr. Gerdes commenced his experiments upon the enrichment of oil gas with acetylene, which have borne such ample fruit on the Continent. He showed that when oil gas is enriched with 25 per cent. of acetylene, a valuable increase in its illuminating power is obtained, without any danger of explosion of the mixture owing to heat or shock. This mixture is now employed to a very large extent on the Prussian railways. The quantity of carbide already used this year for this purpose has reached a total of 3000 tons, and it is computed that before the end of next year 10,000 tons per annum will be needed.

In consequence of the great Continental success of this admixture, application was lodged at the Home Office to sanction such a mixture in England, under the ordinary railway cylinder pressure of 10 atmospheres. The safety of the mixture, and of mixtures considerably richer in acetylene, was completely established by a series of tests carried out in the presence of the Home Office officials; and, in consequence, by an order of the Secretary of State, dated March 28, 1898, a mixture of oil gas with 20 per cent. of acetylene is allowed to be used at a pressure not exceeding 150 pounds on the square inch.

In order to determine the increase in illuminating power given by various percentages of acetylene in oil gas, and whether the mixture could be employed with economy, the following experiments were instituted: Oil gas containing 20 per cent. of acetylene was compressed into a cylinder under a pressure of 10 atmospheres; some of the original oil gas being also compressed in a second cylinder to the same pressure. Both cylinders were then blown off to 5.8 atmospheres, and the illuminating power of each was taken under identical conditions. The burner used was a "40 liter" one, and the results were as follows:

		Illuminating Value.	
Pressure.	Gas Consumption.	Oil Gas.	Oil Gas and Acetylene.
5.8 atmos.	1 cubic foot.	7.4 candles.	15.6 candles.

An analysis of the gas showed that the mixture contained 22 per cent. of acetylene, although but 20 per cent. was originally added, the increase being due to the loss of some of the oil gas, some of the vapors of benzine and toluene in it condensing to the liquid state under the pressure. Working from these figures it will be seen that the addition of 22 per cent. of acetylene caused an increase of illuminating power of 110 per cent., or 100 per cent. with 20 per cent. of acetylene.

With regard to cost, as we have before seen, acetylene, at the present price of carbide, will cost about £1 18s. to £2 per 1000 cubic feet in the holder; and 200 cubic feet will accordingly cost 7s. 8d. The compressed oil gas costs from 6s. to 12s. per 1000. With oil gas at 8s. a 1000, 800 cubic feet will cost 6s. 5d., so that the total cost of 1000 cubic feet of the enriched gas will be 14s. 1d. But as the illuminating value of the mixture is double that of the plain oil gas, there is an economy of 1s. 11d. per 1000. As the oil gas is dearer, the saving will be greater; and, *vice versa*, with cheap oil gas the addition of acetylene would not pay. With oil gas at 6s. 6d. per 1000, there is practically no difference, but the advantages accruing from the use of acetylene would make the mixture more desirable than the plain gas. Amongst these advantages are that the cylinders would last for double the length of time they would with the oil gas, with the one charge, and there would be no formation of liquid hydrocarbons due to compression, with consequent revaporizing when the pressure is reduced, causing inequality in the illuminating power.

CONCLUSION.

The whole question of diluting acetylene with other gases has had a very great interest for me, and I have made many experiments in order to determine how it is that when 10 per cent. of acetylene is added to a diluent such as blue water gas, carbon monoxide, or even hydrogen, the resulting mixture is practically non-luminous; and I have worked out the enrichment value for acetylene for all those gases which might be employed for its dilution. I soon discovered from these experiments that methane is the only diluent which sustains the illuminating power of the acetylene when mixed with it in small proportions; and the fact that the same phenomenon is observable in comparing the illuminating power of mixtures of gases containing only some 30 per cent. of methane gives at once a clue to the methods which must be adopted in making a diluting gas for acetylene.

It is perfectly obvious that in many places it would be a great advantage to have an illuminating gas of about 20 candle-power for general distribution, in the same way as a good coal gas could be used, if such a mixture could be produced at a price comparing favorably with coal gas under the same conditions. Although it would be impossible to use pure methane as the diluent for acetylene, on account of the cost of its production, it is quite easy to make a diluting gas which shall contain 30 per cent. of methane at a comparatively low rate. In order to make this a slightly modified form of water gas generator is employed. The fuel having been blown up to incandescence by an air blast, tar, creosote oil, heavy oil residues, or practically any waste liquid hydrocarbon, is injected into the body of the incandescent fuel by a steam injector or atomizer. If these hydrocarbons were allowed to run into the fuel by themselves, they would simply be burned up to carbon and hydrogen; but steam being injected with them, the steam is decomposed by the fuel, with the formation of water gas, which, to a certain extent, envelops the hydrocarbon, and instead of its undergoing complete decomposition, it is broken down to methane and hydrogen, and mingles with the water gas, whilst any residual carbon is left behind in the fuel. It is quite possible by such means to make a diluting gas containing: hydrogen, 45; carbon monoxide, 15; methane, 30; unsaturated hydrocarbons, 5; carbon dioxide and nitrogen, 5.

This gas costs from 8d. to 10d. per 1000 cubic feet, and has an initial illuminating value of about 10 or 12 candles. On mixing it with five per cent. of acetylene, a gas having an illuminating value of 18 to 20 candles is obtained, which, being a mixture of perfect gases, gives no trouble as regards layering, and which, having the same specific gravity and illuminating value as coal gas, can be distributed and burned in precisely the same way. It is also found that mixtures of this gas with 50 per cent. of acetylene are not detonated, when compressed for railway carriage lighting, by any temperature which it would be possible to attain in the cylinder, and it seems that this method of utilizing acetylene is pre-eminently the one which promises for it the largest and most remunerative future.

I leave my subject with the sincere hope that as time wears on, those points which appear to us now to be difficulties will be made clear, and that in the future cheapened carbide will enable this beautiful hydrocarbon to take its proper place in the foremost ranks of our illuminants.

SOURCE OF LUMINOSITY IN THE WELSBACH MANTLE.*

BY CARLTON LAMBERT, M. A.

Royal Naval College, Greenwich, England.

WELSBACH mantles have effected a great revolution in artificial lighting and have made gas absolutely unapproachable at present by its competitors as a cheap illuminant. The mantle consists, as is well known, of a delicate network of the rare earth, thoria, with a one or two per cent. admixure of ceria. This is placed over a non-luminous Bunsen flame, the heat of which renders the mantel powerfully incandescent. The function of the gas is to generate heat, and that of the mantle is to transform the non-luminous heat energy into luminous light radiation.

It is curious that neither a mantle of pure thoria nor one of pure ceria is at all efficient for light emission, and the wonderful incandescence which results from adding less than two per cent. of ceria to a thoria mantle is difficult of explanation. It is frequently ascribed to catalytic action causing great local intensity of combustion somewhat similar to that which induces the union of oxygen and hydrogen in the pores of spongy platinum. Doubt seems to be thrown on this theory, however, by the fact, established by Le Chatelier, that the light emitted by the mantle is the same whether it is heated in the hot gases at the required temperature before or after they are burned.

Another explanation which commends itself to the writer is based upon the fact that the emitted waves of a pure thoria mantle are largely ultra blue, or too fast for vision, and those from a ceria mantel are ultra red or too slow. It is suggested that the admixture of ceria so loads the thoria particles as to tone down their vibrations into the bright range of the visible spectrum, and thus to make evident to the eye rays which would otherwise be invisible. But to whatever cause it may be due, the emissive power of the Welsbach mantle is certainly remarkable.

CHEAPER GAS FOR POWER PURPOSES IN BOSTON.

CHEAPER gas may be expected to induce a general increase in the use of gas engines, and a movement is now on foot in Boston which may exert a marked influence in this direction. The *Engineering Record* states that Mr. H. M. Whitney, president of the Brooklyn Gas Company, and who controls large coal resources in Nova Scotia, has asked the city authorities of Boston for the privilege of supplying coal gas of 18 candle-power containing less than 10 per cent. of carbonic oxide, at the rate of 75 cents per 1000 cubic feet when used in gas engines for power purposes. The price is to be $1\frac{1}{5}$ cents in engines up to 100 horse-power, $1\frac{1}{10}$ cents in engines from 100 to 200 horse-power, and in engines of more than 200 horse-power the cost will be one cent per horse-power hour.

Mr. Whitney further states that the cost of electric power in Boston is from $3\frac{1}{2}$ to $7\frac{1}{2}$ cents per horse-power hour, depending upon the quantity used. The cost of fuel for a steam engine on a basis of six pounds of coal per horse-power is the equivalent of $1\frac{1}{5}$ cents per horse-power hour, but this economy can not be obtained in small engines that are in common use. The average consumption of small engines is estimated at about ten pounds of coal per horse-power hour when actually at work, and the cost of the power at two cents for the same unit against $1\frac{1}{5}$ cents for the gas engine.

This is considered as the beginning of a movement in the direction of cheap gas that is likely to spread, and if so, its influence as a means of power distribution will be powerful. At these rates, power may be had in Boston for manufacturing purposes at an advantage over steam, or over electricity when produced by steam.

---

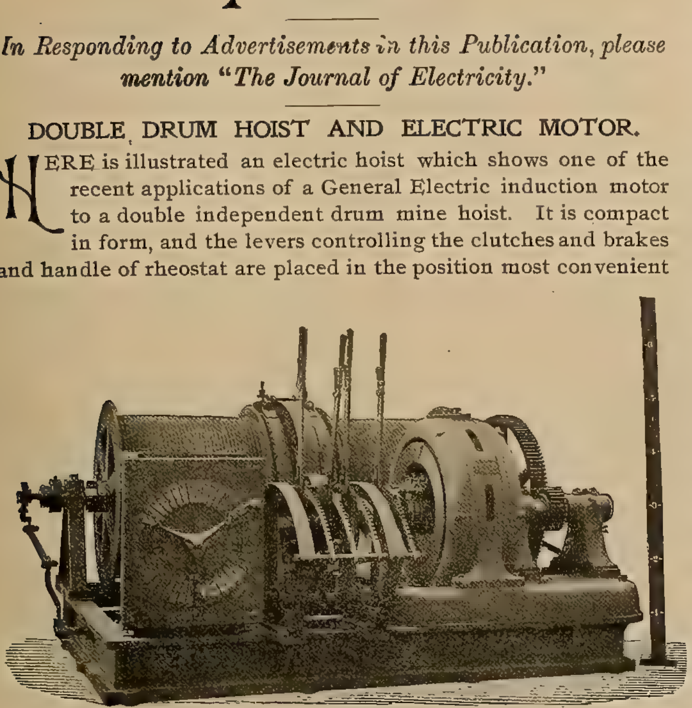
*Abstract from the *American Gas Light Journal*, page 152, January 30, 1899.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

DOUBLE DRUM HOIST AND ELECTRIC MOTOR.

HERE is illustrated an electric hoist which shows one of the recent applications of a General Electric induction motor to a double independent drum mine hoist. It is compact in form, and the levers controlling the clutches and brakes and handle of rheostat are placed in the position most convenient for control by the operator standing on a platform above the floor and having a clear view over the top of the hoist.



Each friction drum is driven through a single reduction gearing by a 100-volt, 12-pole induction motor of 30 horse-power capacity, running at 600 revolutions per minute. Each drum is independent, and is 42 inches in diameter by 40 inches face. Together they hold about 420 feet of ⅞-inch rope. The maximum hoisting speed is 300 feet per minute, and the weight hoisted, *i. e.:* the load, car, and cage, is 2100 pounds. The depth from which the load is to be hoisted is 400 feet from the surface.

HIGH AND LOW FREQUENCY ALTERNATORS.

FOR alternating current electric plants in which lights alone are to be considered, with high potential distribution, high periodicity generating apparatus is desirable both from simplicity and low first cost. When, however, long distance transmission enters as an important factor, a periodicity of 60 cycles, on account of diminished reactive drop in the lines, allows of transmission over a greater distance than by a high periodicity.

The General Electric Company, manufactures alternators of 60 and 125 cycles frequency in both revolving armature and revolving field types. Revolving armature machines of 125 cycles frequency are built in five standard sizes, 30, 60, 90, 120, and 180 kilowatts, each size wound for 1040 or 2080 volts. The low periodicity alternators are wound for 1040, 2080, or 3120 volts and are built in capacities of 60, 90, 120, and 180 kilowatts. All are arranged for belt driving and are set on rails.

The fields are both separately and self-excited, part of the main current being rectified for the self-excitation. The current for the separate excitation of the fields is derived from a small direct current generator driven by belt from a pulley on the end of the armature shaft. The two windings allow of adjustment of the fields to automatically compensate for changes of load, thus giving a practically constant potential at the terminals. The machine may also be over-compounded to compensate for line loss.

The degree of compounding is regulated by a shunt mounted against the inside of the pillow block at the collector end. It is properly adjusted when the machine is under test at the factory.

The magnetic field includes part of the frame which is a cast iron ring with inwardly projecting poles of laminated iron. By this means eddy current losses are reduced and the reluctance of the magnetic circuit diminished. Both separate and series field coils are wound upon removable spools, the winding of double covered copper wire being carefully insulated from the spools themselves.

The armature is iron clad; laminations of soft steel built up on a cast iron spider form the core, and each shunt is carefully japanned before assembly, while to guard against eddy currents thin paper sheets are interposed between adjoining plates at frequent intervals. The core is thoroughly ventilated by air drawn through the spider and circulating in the ventilating spaces between core and windings. The coils are wound on forms and thoroughly taped and insulated before they are placed in the core, in which they are secured by insulating blocks. They are supported at the end by saddles of light metal which give ample support to avoid injury by centrifugal force. This method allows of ready removal of any coil when necessary.

Commutators and collectors are of copper of the highest conductivity, and are mounted on a metal hub keyed to the shaft. The insulation consists of mica and hard rubber so arranged that short circuits and grounds are practically impossible. The collector brush holders are supported on a cast iron standard and insulated from it by hard rubber bushings. The commutator brush holders are supported on a yoke carried by the adjoining pillow block. The bearings are spherical and self-oiling, self-centering, and self-aligning, and of ample length to ensure cool running.

Each alternator, before shipment, is subjected to most thorough tests. The insulation of the separately excited field coils is tested to 3000 volts alternating, and the series coils and armatures at pressures at least double the normal operating voltage.

AN OPPORTUNITY FOR PRUDENTIAL INVESTMENT.

AGAINST gold mining there is no combination of men or capital. In league with gold mining are not only the miners, rich and poor, but the trusts, the corporations, and the governments of the old world and the new world. The peoples of the whole earth are the patrons of this industry, and legislate in its favor. Gold always finds a market and always sells at par. Instead of the old adage, "as good as wheat," is now heard "as good as gold." While values of real estate vary with the seasons, and the products of the soil are ever changing with new conditions, gold, like the laws of the Medes and Persians, changes not. Gold belongs to him who finds it, and there is no respecter of persons. Our commercial cities may decay, agricultural communities may languish, but California's mining regions are prosperous to a degree hardly known since the Argonauts of '49 crossed the plains. The certainty of its value and the modern methods of mining have eliminated its former speculative features and have made this the most popular industry in the Golden State. Since General Sutter, in 1848, made that wonderful discovery in the mill race, California has produced $1,250,000,000 of gold; from 1850 to 1862 an average of $55,000,000 annually, and in the year of 1897 about $17,000,000. In the one county of Tuolumne, hereafter particularly referred to, there was produced last year of the yellow metal nearly $2,000,000.

In view of the foregoing, and other reasons, a company has been organized to develop three exceedingly promising mines, the Dewey, Sampson, and Schley, located in one of the best mining regions in the world. The public generally is invited to consider well the merits of the business proposition presented below, as the opinion is held that an unusual opportunity is offered for an investment.

The Dewey, Sampson and Schley mines are located on the Tuolumne river, five miles northeast of Groveland, Tuolumne county, which is recognized as the second greatest bullion producing county in California. Of the $1,250,000,000 taken from the placer mines of this state, Tuolumne has contributed $215,000,000, or about one-sixth of the whole amount.

These mines are on the same ledge as the Buchanan and Kanaka, the former being one mile north, having a bullion record of $600,000; the latter being one and one-half miles south, a dividend-paying mine owned by Fresno capitalists.

These three mines each consist of 1500 feet long by 600 feet wide; in all 4500 linear feet on the ledge. The croppings are prominent the full length of the three claims. The vein is a true fissure, and the hanging and foot walls are each of slate. Commencing near the water's edge there is a tunnel fifty feet long; at an elevation of twenty feet above this tunnel is another tunnel fifty feet long, each tunnel being five feet wide and seven feet high. There has also been some surface prospecting at various points on the ledge to determine its value, but it is not of a permanent character. The ledge is six feet wide from wall to wall, and is all milling ore.

These mines were first located in 1873; in fact nearly all of the development work on them was done over thirty years ago. At that time there was on the property a five stamp mill, which later on was burned down. In 1885 B. A. Ogden built an arastra on the property and worked considerable ore from one of these mines. Over his signature he states that the average yield of the ore worked was $11.00 per ton. From the first discovery of these mines the ground has been considered valuable, and since the development of other rich mines on the same ledge and in the immediate vicinity, this ground has greatly increased in value. The returns show that from about 500 tons of the ore milled in the seventies, the average milling value of the ore at that time was $6.25 per ton. As there were in the mine at that time no inclines, cross-cuts, or stopes, the ore milled was taken wholly from the two tunnels referred to. Also at this early date, the sulphurets were regarded as waste, but now the sulphurets, by the modern process of working, yield from $300 to $400 per ton. It is a conservative estimate that $6.25 per ton is the average value of this ledge. The character of the ore is free gold and sulphurets, the latter being valued at from $300 to $400 per ton. The ore is free milling and easily worked.

The proposed permanent tunnel, through which the mines will be worked, is just avove the water's edge of the Tuolumne River. Abundant water power for the mill is practically on the mill site. Also, within 100 yards of the mouth of the tunnel is a splendid location for an electric plant, to be run by free water power. By running on the ledge the amount of stoping ground gradually increases, as progress is made in the tunnel, until at a point 700 feet from its beginning, where there will then be 2600 feet of backs—that is to say, the end of the tunnel will be 2600 feet beneath the apex of the hill. Having reached this point, this will be, with two exceptions, the deepest mine in California. The ore will be run on cars from the mine to the mill, thus avoiding all expense of hoisting, and at the same time the tunnel will be used for draining the mine of water, thus obviating the expense of pumping.

With these facilities, which are unsurpassed anywhere else in California, the cost of mining and milling the ore will not exceed $1.25 per ton; $6.25 ore would, therefore, yield a net profit to the company of $5 00 per ton. Working sixty tons per day there would be a net profit of $300 per day, or $9000 per month. The estimated cost of running the tunnel, five feet wide and seven feet high, is $5.00 per linear foot. Having run the tunnel 400 feet, there should be plenty of milling ore for a 20-stamp mill. This work would cost $2000. A 20-stamp mill would cost about $15,000. By an expenditure thus of about $17,000, this group of mines should be handsomely dividend paying.

The company is incorporated for $250,000—250,000 shares of stock at $1.00 per share. Of these 120,000 shares have been disposed of in the purchase of the property. The remaining 130,000 shares, which is a majority, is treasury stock. This is to be sold, the proceeds to go towards the development of the mines and the purchase of a mill. The stock first sold will be at par. The price of the stock later on will depend upon the developments in the properties, and may be advanced at any time by the board of directors. The stock sold at $1.00 per share will be on terms as follows: Five cents per share at the time of executing the contract, and five cents per month thereafter until the amount of $1.00 per share shall have been fully paid. Each share of stock represents a pro rata interest not in an option or bond, but an interest in the property itself.

Under a guarantee of the company, all stock is non-assessable. The board of directors agree with every purchaser of the stock that the mines will be kept free from debt; that no expense of any kind shall be incurred beyond the limit of the funds on hand; that, in short, under no circumstances, will there ever be an assessment levied on the stock for any purpose whatever. As this is a provision of the by-laws the board of directors are individually and collectively held liable to the stockholders for any violation of this agreement made with each and every stockholder. The company owns the titles to the mines. The title is perfect and the property is free of incumbrance.

These mines are owned by The East Belt Gold Mining Company, the San Francisco office of which is at 602 Market street. Of the personnel of its board of directors, the president, Hon. C. S. Young, is ex-State Mineralogist of Nevada, and more recently the right of way agent of the S. F. & S. J. R. R. Company. The vice-president is John Moss, Esq., traffic manager of the S. F. & S. J. R. R. Company, now a part of the Santa Fé R. R. Company, 321 Market street, San Francisco. The secretary is H. S. Allen, Esq., a mining man of state reputation, who resides at the Grand Hotel, San Francisco. The treasurer is E. P. Barrett, who is ex-member of the San Francisco Board of Education, and now a member of the San Francisco Stock and Exchange Board, and of the firm of J. S. Barrett & Co., stock brokers, 327 Pine street, San Francisco. Director George Beaudet is of the wholesale firm of Daveluy & Co., Sonora, Cal.

TABLE OF CONTENTS.

Illustrated articles are designated by an asterisk (*); Editorials by a dagger (†); Passing Comment by a double dagger (‡), and Industrial by a section mark (§).

Gas

Acetylene—IV, by Prof. Vivian B. Lewes, F. I. C., F. C. S. 47
Cheaper Gas for Power Purposes in Boston 50
Source of Luminosity in the Welsbach Mantle, by Carlton Lambert, M. A. 50
‡The Future of Non-Luminous Gas 45

Literature

‡*Cassier's* Electric Railway Number 46

Mining

§An Opportunity for Prudential Investment 51
‡Breaking Down the Barriers of Conservatism 45
*§Double Drum Hoist and Electric Motor 51

Steam

The Trend of Central Station Design, by Bion J. Arnold 39

Transmission

§High and Low Frequency Alternators 51
†The Limits of Electric Power Transmission 44
*The Monterey and Pacific Grove Lighting Plant, by Harry J. Bean, A. B., E. E. 37
‡The Mount Whitney Transmission 46

Transportation

Railway Electrolysis Popularized (Communicated) 42

THE JOURNAL OF ELECTRICITY.

VOLUME VII. SAN FRANCISCO, APRIL, 1899. NUMBER 4.

INDUSTRIAL GAS.

BY FRANK H. BATES.

IT is only within recent years that engineers, in their efforts toward securing higher economy in fuel consumption, have directed attention to a study of the properties of gases. That such is now the case, however, is evidenced by demands which have led to the invention of such instruments as, for instance, Elliot's portable apparatus for technical gas analysis, Carpenter's calorimeter for coal, and Junker's calorimeter for gases and oils—all fashioned for the practical engineer whose time seldom permits of protracted laboratory experiments. In considering this subject the thought occurred to the writer that the publication of a series of complete and largely original papers on "Industrial Gas" would prove of interest and value, particularly in that it appears to be but a matter of time when the gas manufacturer will supply the manufacturing world with gaseous fuel.

Without further preface, the subject will be treated under the following general divisions:

I. Methods of Gas Analysis.
II. Heating Value, or Calorific Power.
III. Fuel Gas Analysis, with a view to increasing Furnace and Boiler Efficiency.
IV. Methods of Production.

I.—METHODS OF GAS ANALYSIS.

Apparatus. For furnace and chimney gases, consisting principally of carbon dioxide, carbon monoxide, oxygen and nitrogen, by far the most convenient apparatus is the Orsat, (Fisher's modification) arranged in a portable case.

For furnace or chimney gases, producer gas, and illuminating gas, where great accuracy may be sacrificed to rapidity of operation and convenience, Elliot's latest modification with explosion burette, half size, and arranged in a traveling case, is suitable.

For accurate laboratory analysis, use Hemple's apparatus.

It sometimes happens that one is so situated as to make it desirable to obtain a rough estimate, or an approximation, of the constituents of a gas, there being no standard apparatus at hand. In such event, the tubes illustrated in Figure 1 can be quickly made up from plain glass tubing, of about 20 millimeters* (¾ inch) internal diameter. First bend and draw out the projecting end *d* of the tube A, retaining the conical form and making the external diameter about 4.7 millimeters ($^3/_{16}$ inch). Make the glass tube *d* corrugated so as to permit a rubber tube to be securely fastened thereon by wire, and have the tube *d* project from the main tube some 38 millimeters (1½ inches) thus providing for the wooden stand *e*, which is to be slotted to allow of its receiving the tube, and of the latter being secured thereto by a clasp. This finished, cut the glass tube off to a length of about 500 millimeters (20 inches), and shape the end *c* down to an internal diameter of about 0.8 millimeters ($^1/_{32}$ inch). Make this end 32 millimeters (1.25 inches) in length, and form its outside to correspond to the end *d* for a rubber tube connection. Next make up the tube A′ of similar diameter but one-third longer. The projection *d′* is identical with *d*, but at *c′* the tube, instead of being conically drawn out, as at *c*, is enlarged to a funnel shape, forming a mouth for the reception of liquids.

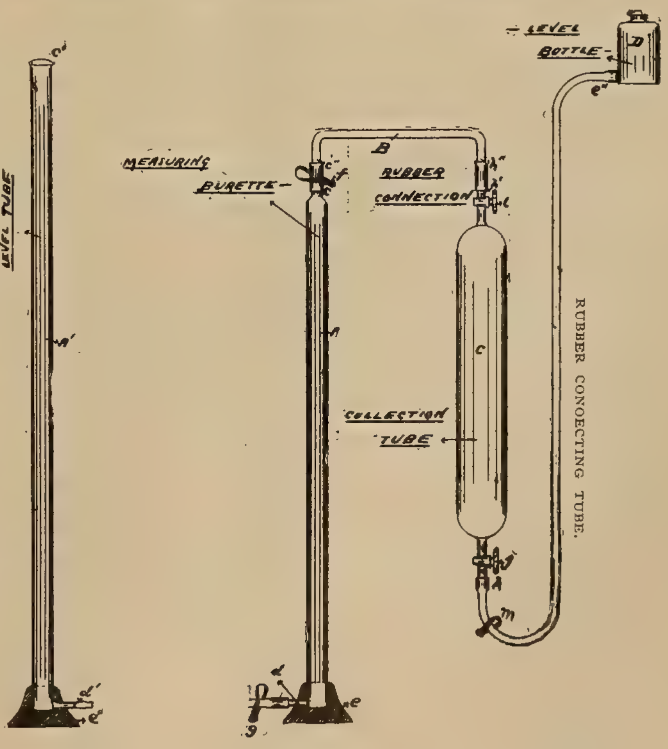


FIGURE 1.

Having this complete, fasten a piece of seamless rubber tubing on the end *c* of the tube A by wire ligatures, leaving some 40 millimeters (1.5 inches) of the tube length above the glass for the purpose of inserting a connecting piece thereon. Fasten the end of a piece of rubber tubing one-half meter (19.6 inches) long to the projection *d*, and a similar piece to the end *d′*, connecting the two free ends by a piece of glass tubing, thereby obviating the necessity of removing the wired ends at *d* and *d′* when cleaning the tubes. The tube A, which is termed the measuring burette, is thus connected to tube A′, termed the level-tube.

---

* To reduce millimeters to inches, multiply by .03937, or divide by 25.4.

To calibrate A, proceed as follows: First ascertain the amount of water contained by, say, 325 millimeters of the length of the tube A′. In this instance, as the internal diameter of the tubing is 20 millimeters, the quantity would be 102.102 cubic centimeters,[*] or each millimeter of the length of the tube would contain about 0.31416 cubic centimeters. Now fasten a thin strip of paper, scaled to millimeters, and about 400 millimeters in length, on the outside surface of the tube A′, to serve temporarily. Place a pinch-cock, *f*, on the rubber tube close to the end *c*, and place another pinch-cock, *g*, in a similar manner on the rubber tubing close to the end *d*. With both pinch-cocks open, fill the two tubes with water, having the water overflow at the end of the rubber tube *c*, the capillary tubing B not being attached as yet; then close the pinch-cocks *f* and *g* and partially empty the level-tube A′ so that the level of the water is a little above the lowest reading of the paper scale. Open the pinch-cock *g*, then by raising the level-tube A′ so that the water in it will be on the same level as the water in the burette A (which is at the very top or end *c*), the contents of both tubes will be under equal pressure; *i. e.*, under equal atmospheric pressure. Notice at this time the reading of the water level in the level-tube A′ on the improvised scale, taking care to read the position of the lowest point of the sharply defined, crescent-shaped meniscus formed at the surface of the water.

For the purpose of illustration, consider this reading to be 10 millimeters from the bottom of the scale. Now lower the level tube A′, and open the pinch-cock *f* to admit air so as to allow the water in burette A to drop about 42 millimeters (1.6 inches) from its former level—the top of the tube at *c*. After waiting three minutes for the walls of the tube to drain, take the reading of the water level on the scale on level-tube A′, under atmospheric pressure, by bringing the level of the water in both tubes to the same height. Suppose the reading to be 20 millimeters, then $20 - 10$ (the former reading) $= 10$ millimeters, and as each millimeter was found to contain 0.31416 cubic centimeters, 10 millimeters would equal 10×0.31416 or 3.1416 cubic centimeters, the amount of air admitted.

Keep the level of the liquid in both tubes at the same height and then mark the line of water level on the burette A with a file. Now, in a similar manner as before, admit sufficient air to make a total of 100 cubic centimeters, which in the present case, would correspond to 318.3 millimeters in the scale of the level tube. In doing this no difficulty need be experienced if care is taken to admit very little air as the required amount (100 cubic centimeters) is approached. The level-tube A′ should be raised frequently to make the readings until about the amount is obtained when three minutes should be allowed to drain the water from the walls of the burette before making the final measurement.

Now with the liquid in the level-tube A′ and in the burette A at the same height, mark with a file the level of the water in burette A. This corresponds to 100 cubic centimeters, measuring from the top at *c*. Cut a strip of paper of a length equal to the distance between the two file marks, and on this paper lay off a scale in proportion, divisioning it into tenths of cubic centimeters, gluing it on to the measuring burette A and shellacking. The scale on the level-tube A′, may now be discarded, and there has been thus improvised an apparatus that, in lieu of a better one, will suffice for rough work.

Operation. The pinch-cocks *f* and *g* are first opened by simply slipping them off over the ends of the glass tubes *c* and *d*, and they remain so. Water is poured into the mouth *c′* of the level-tube A′, until it overflows from the short rubber tube on *c*, when the pinch-cocks *f* and *g* should both be closed. During the operation of filling with water, the level-tube A′ should be held at such a height with respect to the burette A, that it may fill the former about two-thirds full. Now make connection with the collection tube C, containing the gas sample, by means of the capillary tube B, which should be as short as possible and bent at right angles at a point about 30 millimeters from each end. In joining the capillary tube B, first prepare it by filling with water and wiping a little vaseline over the ends *c″* and *h″* where the rubber tube connections are to be attached. By means of a small dropping pipette also fill the short pieces of rubber tubing in the ends *c* and *h′* of the burette and collection tube respectively, and by slipping one end of the capillary tube into the rubber tube at *c* and the other end into the end of the rubber tube at *h′*, all air will be excluded. The end *k* of the collection tube C should be connected by a piece of rubber tubing a meter (39.37 inches) long to the level-bottle D, after which slip a pinch-cock *m* on the rubber tube near *k*.

The above connections having been made, next place the level-tube A′ on the floor with burette A resting on a stand, and raise the level-bottle D to a support arranged above the collection tube C. Open the pinch-cocks *g*, *f* and *m* and the glass-cock *j* in the collection tube C, thereby putting the collection tube C and level-bottle D in connection. By opening the glass cock *i* the pressure of the column of water between the collection tube and the level-bottle will force the gas over into the burette A, and in this it will be assisted by the expansion of the water in A, due to the relatively low position of level-tube A′. Pass over about 50 cubic centimeters of gas, close the glass-cock *i*, and agitate the water in the burette vigorously in order that it may become saturated with the gas. Next open the glass-cock *i*, raise the level-tube A′ and lower level-bottle D, causing the gas to return to the collection tube. Again agitate the collection tube, after which transfer the gas back and forth a few times, thoroughly saturating the water in both the level-bottle and level-tube, to prevent the water washing out the soluble constituents of the gas when making the analysis.*

---

[*] To reduce cubic centimeters to cubic inches, divide by 16.383.

This preliminary operation complete, force all the gas from the burette A by raising the level-tube A′ and lowering the level-bottle D. Close the pinch-cocks *f* and *m* and the glass-cocks *i* and *j*, and disconnect the rubber tubing of the level-bottle D from the collection tube—the pinch-cock *m* serving to prevent the out-flow of water; also remove capillary B from both the collection tube and burette. Fill the short rubber tube at *c* and the capillary tube B with water, and after wiping the ends of the latter with vaseline, make connections with a new collection tube, containing sample gas.

One is now ready to proceed with the analysis proper.

Analysis. By lowering the level-tube and raising the level-bottle, opening pinch-cocks *f* and *m* and glass-cocks *i* and *j*, about 103 cubic centimeters of gas is admitted to the burette, when pinch-cock *f* and glass-cocks *i* and *j* are closed, the capillary tube disconnected, and, together with the collection tube and level-bottle, laid aside. Close pinch-cock *g* and place level-tube on the support above, thereby creating a pressure due to the weight of the water column above the water level in the burette. After waiting three minutes for the walls of the burette to drain, open pinch-cock *g* just sufficient to allow the lowest point of the meniscus of the water to rise to the 100 cubic centimeter mark in the burette, taking precaution to have the eyes on the same level. There is now contained in the burette 100 cubic centimeters of gas under pressure a trifle greater than atmospheric. Open pinch-cock *f* to the air for but a moment, thus allowing the excess pressure to escape. By now opening pinch-cock *g* and holding the level-tube so that the surface of the liquid therein will be on the same level with the liquid in the burette, thus putting our gas under atmospheric pressure, the level in the burette will be found to coincide with the 100 cubic centimeter mark.

In these illustrations, 100 cubic centimeters of gas is taken to simplify matters, as the readings thus give percentages direct.

Determination of Carbon Dioxide. We first determine the quantity of carbon dioxide (chemical formula CO_2) by absorption with a reagent.† The reagent used as an absorbent may be potassium hydroxide, sodium hydroxide, or barium hydroxide. The first is to be preferred, owing to its quick action, but the last is employed to advantage when the quantity of carbon dioxide is very small.

To treat the gas with the reagent, lower the level-tube to expand the gas in the burette until the level of the water lowers almost to the top of foot-piece *e*; then close pinch-cock *g*, and empty the level-tube and tubing of water and then partially replace it with the absorbent. Raise the level-tube with the left hand as high as the rubber tubing permits, when, by opening pinch-cock *g*, a considerable quantity, diluted with the water left in the rubber tubing, will be forced into the burette. Lowering and raising the level-tube will thoroughly mix the reagent and the water and assist in the absorption of the carbon dioxide. By closing pinch-cock *g* and agitating the burette, all the gas will be brought into intimate contact with the absorbent. Note the readings from time to time, and when no further diminution of volume takes place, open pinch-cock *g*, and after waiting three minutes for the walls of the burette to drain, measure the gas volume under atmospheric pressure by bringing the level of the liquid in both tubes to the same height. This reading, subtracted from 100, will give the per cent. by volume of carbon dioxide in the gas.

Determination of Illuminants. Again lower the gas in the burette as much as possible, and in doing so, exercise the same care as before in order to prevent the liquid in the burette from dropping too low lest the gas gets into the tube and escapes. Then close the pinch-cock *g*, and empty the level-tube of the reagent, afterwards rinsing out with water. Next, add a little water in which a few drops of hydrochloric acid was previously mixed, to neutralize the remaining reagent in the lower portion of the burette.

The next determination is that of the illuminants or heavy hydrocarbons. These consist principally of ethylene, (furmula $C_2 H_4$) the absorbent for which is bromine water. The level tube is nearly filled with water and a little bromine is added with a dropping pipette. The gas residue is then treated with this reagent as in the previous case until no further action takes place. In the present instance, however, before measuring the amount of absorption, it will be necessary to empty the level-tube of the bromine water, first closing pinch-cock *g*, and then partially replacing, not with the next reagent, but with potassium hydroxide, with which treat the gas. This is necessary after using bromine, owing to its high tension, or tendency to vaporize. The potassium hydroxide absorbs this vapor, after which the gas may be measured and the true percentage of ethylene may be ascertained by direct reading.

Determination of Oxygen. Again lowering the gas in the burette and emptying the level-tube, rinse and partially fill with potassium pyrogallate for the absorption of oxygen, (symbol O). The method of treatment in this case is similar to the preceding, except that no vapors are formed, and, in consequence, treatment with potassium pyrogallate alone suffices.

Determination of Carbon Monoxide. The percentage of oxygen determined, empty the level-tube, rinse with water, and add the next absorbent, cuprous chloride, for the absorption of carbon monoxide, (formula CO). This is our last determination with this apparatus. An example may serve to illustrate the foregoing operations.

Partial analysis of Donson producer gas:

The water in level-tube and level-bottle was saturated with the gas.

---

* With the present apparatus this is almost a useless precaution, but is given to familiarize the reader with principles to be followed in more exact analyses.

† Most of the constituents of coal gas may be removed or absorbed by certain liquid reagents, there being exceptions, however, such as hydrogen, methane, nitrogen, etc., which are removed by combustion.

From another collection tube 100 cubic centimeters of the sample gas was taken for analysis.

After treating with potassium hydroxide until no further absorption took place, the gas volume measured 93.43 cubic centimeters; hence, 100—93.43=6.57 cubic centimeters, the amount of carbon dioxide in 100 cubic centimeters of sample gas, or, carbon dioxide is 6.57 per cent.

Level-tube emptied, rinsed with water, and a little hydrochloric acid added to neutralize the potassium hydroxide. Gas is treated with bromine water until absorption is complete, level-tube then emptied, rinsed, and partially filled with potassium hydroxide to absorb the bromine vapors. Gas volume then measured 93.12 cubic centimeters; hence, 93.43 (last reading) —93.12=0.31 cubic centimeters, the amount of ethylene in 100 cubic centimeters of sample gas, or, ethylene is 0.31 per cent.

Level-tube emptied and rinsed, and without adding hydrochloric acid, gas is treated with potassium pyrogallate until no further absorption, and volume then measured 93.09 cubic centimeters; hence, 93.12 (last reading) —93.09=0.03 cubic centimeters, the amount of oxygen present in 100 cubic centimeters of sample gas, or, oxygen is 0.03 per cent.

Level-tube emptied, rinsed, and gas treated with cuprous chloride until no further absorption. Gas volume was 68.02 cubic centimeters; hence, 93.09 (last reading) —68.02=25.07 cubic centimeters, the amount of carbon monoxide present in 100 cubic centimeters of sample gas, or, carbon monoxide is 25.07 per cent.

Other constituents of the gas could not be determined with this apparatus. They must be determined by combustion, as will be shown later. This apparatus would suffice, however, for furnace or chimney gases composed of carbon dioxide, oxygen, carbon monoxide, and nitrogen. The nitrogen in this case would be found by difference; *i. e.*, by subtracting the sum of the other gases from 100, which would give its percentage.

Properties of the Gases. CARBON DIOXIDE. Synonyms: carbonic acid gas, fire-damp, after-damp, etc. Formula CO_2. Molecular mass (generally termed weight), 44; more correctly, according to atomic weights of Meyer and Seubert, 43.89. Specific gravity compared to air, 1.5290. Weight of one liter, 1.977 grams; weight of one cubic foot, 0.12343 pounds.

An irrespirable, colorless gas, denser than air, having a pungent odor, and acid taste. It is fatal to animal life extinguishes combustion. At normal conditions of temperature and pressure (0 degree C. and 760 millimeters of mercury) water absorbs or dissolves about one volume of carbon dioxide; as the pressure increases, temperature remaining constant, a greater absorption takes place, an additional volume being absorbed for each atmosphere of pressure added. Carbon dioxide becomes liquid at a pressure of 38.5 atmospheres and 0 degree C., with a specific gravity of 0.923. At —65 degrees C., the liquid solidifies to a transparent mass like ice. A temperature of —140 degrees C. may be obtained by means of frozen carbon dioxide moistened with ether and placed in a vacuum.

Preparation: Carbon dioxide may be prepared by the action of an acid upon some carbonate:

$$\underset{\text{Calcium Carbonate}}{C_aCO_3} + \underset{\text{Nitric Acid}}{(HNO_3)_2} = \underset{\text{Calcium Nitrate}}{C_a(NO_3)_2} + \underset{\text{Water}}{H_2O} + \underset{\text{Carbon Dioxide}}{\overset{\uparrow}{CO_2}}$$

ETHYLENE. Synonyms: olefiant gas, ethene, hydrogen di-carbide. Formula C_2H_4. Molecular mass 28; according to Meyer and Seubert, 27.94. Specific gravity compared to air, 0.9847. Weight of one liter, 1.273 grams; weight of one cubic foot, 0.07949 pounds.

An irrespirable, colorless gas, with odor of ether. Soluble in about eight times its volume of water. Combustible, emitting a brilliant white flame when burning in air, and evolving much smoke. Mixed in the proportion shown in formula below (one volume of ethylene to three volumes of oxygen), explodes violently on ignition. At 9.8 millimeters pressure, its evaporation produces a temperature of —150.4 degrees. It is the principal constituent of the fixed illuminants or heavy hydrocarbons.

The reaction with oxygen is:

$$C_2H_4 + 3O_2 = 2CO_2 + 2H_2O$$

One volume of ethylene + three volumes of oxygen unite to form two volumes of carbon dioxide and two volumes of water, but the water may be considered as possessing no volume (owing to contraction in changing from a gaseous to liquid form), consequently the contraction due the combustion of ethylene is $2C_2H_4$; 1 volume +3 volumes=4 volumes; 4—2=2 volumes contraction, or, for every volume of ethylene burned there is a resulting contraction of two times the volume of ethylene, or, contraction equals $2C_2H_4$. A reference to the reaction also shows that two volumes of carbon dioxide are formed for each volume of ethylene burned, or the carbon dioxide formed equals two times the ethylene burned; $CO_2=2C_2H_4$.

Preparation: Ethylene may be prepared by the action of sulphuric acid upon alcohol: $C_2H_6O=C_2\overset{\uparrow}{H}_4+H_2O$.

OXYGEN. Symbol O. Atomic mass, 16; or, according to Meyer and Seubert, 15.96. Valence II. Molecular mass, 32; or, according to the atomic weight of Meyer and Seubert, 31.92. Specific gravity compared to air, 1.1051. Weight of one liter, 1.4298 grams. Weight of one cubic foot, 0.08948 grams.

Oxygen is respirable when pure, accelerating the respiration; a colorless, odorless, tasteless gas, of greater density than air, and slightly soluble in water, 100 volumes of water at 0 degree C., taking up 4.1 volumes of oxygen. The union of any element with oxygen is what is generally implied by combustion. The action of oxygen in air is much less active in such union than when pure, owing to the dilution with nitrogen. Combustion with oxygen is attended with light and heat. Oxygen becomes liquid at 20 atmospheres of pressure, at a temperature of —136 degrees Fahrenheit.

Preparation: Oxygen may be prepared by heating potassium chlorate, mixed with one-quarter of its weight of manganese dioxide:

$$(K\ CL\ O_3)_2+MNO_2=(K\ CL)_2+MNO_2+(\overset{\uparrow}{O_2})_3$$

CARBON MONOXIDE. Synonyms: carbonic oxide, carbonyl. Formula, CO. Molecular mass, 28; according to Meyer and Seubert, 27.93. Specific gravity compared to air, 0.9674. Weight of one liter, 1.251 grams. Weight of one cubic foot, 0.07810 pounds.

It is an irrespirable, colorless gas, with suffocating odor. One per cent. in air proves fatal to life. Combustible, burning with a blue flame. It is a constituent of water gas, made by passing steam over incandescent fuel, and has, in this connection, been the topic of much discussion and even legislative interference, owing to the difficulty of detection and fatal effects on life. It is condensible to a liquid at −139.5 degrees C., and 35.5 atmospheres.

The reaction with oxygen is $CO+\frac{1}{2}O_2=CO_2$.

One volume of carbon monoxide combining with one-half volume of oxygen forms one volume of carbon dioxide; or, the contraction is $1\frac{1}{2}-1=\frac{1}{2}$ or $\frac{1}{2}CO$. The carbon dioxide formed equals the volume of carbon monoxide burned, or $CO_2=1CO$.

Preparation: Carbon monoxide may be prepared by heating oxalic acid with strong sulphuric acid:

$$\underset{\text{Oxalic Acid}}{H_2C_2O_4} = \underset{\text{Water}}{H_2O} + \underset{\text{Carbon Dioxide}}{CO_2} + \underset{\text{Carbon Monoxide}}{\overset{\uparrow}{CO}}$$

As seen, CO_2 is also present in the products, but can be removed by treating with potassium hydroxide, absorbing it as in gas analysis.

Nitrogen. Symbol N. Atomic mass, 14; according to Meyer and Seubert, 14.01. Valence I, III, and V. Molecular mass, 28; according to atomic mass of Meyer and Seubert, 14.02. Specific gravity compared to air, 0.9714. Weight of one liter, 1.2561 grams; weight of one cubic foot, 0.07842 pounds.

Nitrogen is an irrespirable (it exerts no injurious action upon animal tissue, but does not support life), colorless, odorless, and tasteless gas of less density than air, slightly soluble in water, 2.5 volumes being absorbed by 100 of water. It is inert as regards combustion, uniting with oxygen only at an elevated temperature. Cooled to −150 degrees C., in liquid ethylene, boiling under a pressure of 10 millimeters; nitrogen is liquefied by a pressure of about 30 atmospheres.

Preparation: Nitrogen may be prepared by heating ammonium nitrate:

$$\underset{\text{Ammonium Nitrate}}{(NH_4)\,NO_2} = \underset{\text{Water}}{(H_2O)_2} + \underset{\text{Nitrogen}}{\overset{\uparrow}{N}}$$

Preparation of the Reagents Employed. Potassium Hydroxide. Dissolve 500 grams of commercial hydroxide (which has not been purified by alcohol) in one liter of pure water. It is ready for use as soon as made. Capacity: One cubic centimeter absorbs 40 cubic centimeters of carbon dioxide.

Sodium Hydroxide. Make a saturated solution of the commercial hydroxide in pure water.

Barium Hydroxide. Make a saturated solution of barium oxide in water, (the barium oxide slakes).

Of these reagents, the first is preferable owing to its rapidity of action, the second to its cheapness, and the third to its accuracy where the carbon dioxide is in small quantities.

Bromine Water. Made by adding a little bromine to a liter of water, very little being required to saturate the water, causing it to give off bromine vapors.

Potassium Pyrogallate. To 50 grams of pyrogallic acid add 1000 cubic centimeters of potassium hydroxide as made above. Keep well corked owing to its affinity for the oxygen of the air. It is ready for use as soon as made. Capacity: One cubic centimeter absorbs two centimeters of oxygen.

Cuprous Chloride: Place in a liter reagent bottle 300 grams of copper oxide, and on this arrange a bunch of copper wire to reach the entire length of the bottle. Then fill with hydrochloric acid (specific gravity 1.10). The bottle is shaken, well corked to prevent the absorption of oxygen, and allowed to stand in the dark till perfectly clear, when it is ready for use. Exposure to light will cause it to assume a brownish color, which does not affect its action, however. Capacity: One cubic centimeter absorbs one cubic centimeter of carbon monoxide.

Examination of Furnace or Chimney Gases by means of the Orsat Apparatus. With the apparatus already considered, the gas was drawn into a measuring burette and successively treated by the absorbents, which (in the case of potassium pyrogallate and cuprous chloride), owing to exposure to the oxygen of the air during the treatment, could be used but a few times before their powers of absorption became exhausted.

Orsat devised an apparatus whereby the reagents are protected from the air, and in which the gas itself is brought in contact with the absorbents. It is only to be regretted that the scope of the apparatus is so limited. It offers, however, a most convenient means for the determination of carbon dioxide, oxygen, and carbon monoxide by absorption, and nitrogen by difference, these being the gases found as constituents in furnace and chimney analyses.

Description. Consists of three double pipettes, B, C, and D, Figure 2, made stationary in the case and connected by means of capillary tubing to a measuring burette A, enclosed by a water jacket. Glass stop-cocks E, F, and G close each pipette to the main capillary, and the glass stop-cock H, thereon, affords an inlet for air from the end J. A level-bottle L, provides a means of transferring the gas. To the rear of the pipettes B, C, and D, and connected by glass tubing, are three similar pipettes, whose ends, *s*, *s'*, and *s''*, are connected by rubber tubing with a small, flexible rubber bag, which acts as a seal, preventing the absorption of oxygen from the air by the reagents in the pipettes. The water-jacket may, under ordinary conditions, be simply filled with water, which will tend to prevent slight changes of temperature affecting the gas volume. When the apparatus is so situated as to be subject to draughts or sudden changes, —although this should be avoided when possible—connections should be made with the water supply, so as to have a circulation of water in the jacket, which will secure a fairly even temperature.

Figure 2 shows Fisher's modification of the Orsat, which is of small size and arranged for convenience in traveling.

Figure 3 shows a slight modification known as Petrizilka's, with one universal stop-cock, dispensing with the four small ones.

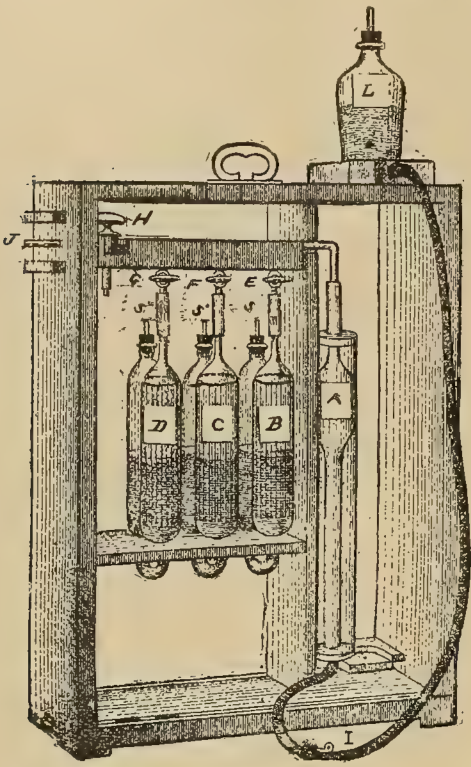


FIGURE 2.

Manipulation. The level-bottle L is filled with pure water, and with stop-cocks E, F, and G closed, and H opened, the measuring burette is partly filled by raising level-bottle L, forcing air through the exit J. By closing stop-cock H and lowering level-bottle L, the air remaining in the burette and capillary is expanded, so that on opening stop-cock E, the reagent in pipette B will be drawn up to a point just below the connecting rubber M, when stop-cock E is closed and the reagents in pipettes C and D similarly raised to corresponding positions. This done, open stop-cock H, and by raising level-bottle L, force all the air from both the burette A and the capillary tubing, displacing by water which will overflow from the end of capillary at J, when close stop-cock H.

Preliminary to the analysis proper, make connections with a collection tube of sample gas and the end J, of capillary tubing of the apparatus, taking same precautions as before to expel all air from the rubber tube and connecting tube, if one is used. Draw in about 50 cubic centimeters of gas (there is contained 100 cubic centimeters from the stop-cock H in the capillary tube, to a point marked 100 cubic centimeters near the bottom of the burette, and the graduations are in tenths of cubic centimeters), by lowering level-bottle L. As soon as the gas is admitted, close stop-cock H, and raise and lower the level-bottle to cause the gas to come in through contact with the water, thus saturating the latter with the absorbable constituents of the gas. Open stop-cock H and expel the gas, filling completely the burette and capillary with the saturated water, and on its overflowing at J close the stop-cock H. We are now ready for our sample for analysis, so draw in through end J, in a similar manner, a little more than 100 cubic centimeters,—say, for instance, 101 cubic centimeters—closing stop-cock H immediately on securing that amount. Wait one minute for the walls of the burette to drain, and then close the pinch-cock I on the rubber tube connecting the level-bottle and the burette, close to the latter. By raising the level-bottle L, a pressure is created, due to the height of the column of water, so that on gradually opening the pinch-cock I, the gas is forced up in the burette. With the eyes on the level of the 100 cubic centimeter mark on the burette, close the pinch-cock I just as the lowest point of the meniscus reaches the mark, when we will have 100 cubic centimeters of gas at little more than atmospheric pressure. By opening the stop-cock H for but a moment, this excess will escape to the air, leaving us exactly 100 cubic centimeters of gas. By opening pinch-cock I and bringing the level-bottle L to such position that the level of the liquid contained corresponds to the level of the liquid in the burette, we will find that the level in the burette will be at the 100 cubic centimeter mark, proving the amount of gas contained to be 100 cubic centimeters at atmospheric pressure.

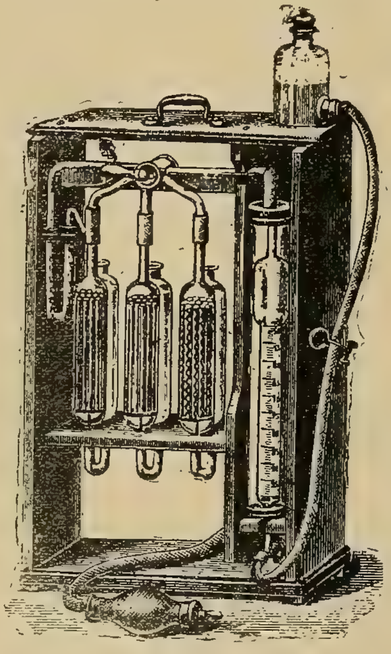


FIGURE 3.

Determination of Carbon Dioxide. We may now treat our gas to the first absorbent, potassium hydroxide, which is contained in pipette B. Opening stop-cock E and raising level-bottle L, forces the reagent down and up into the rear pipette, laying bare the contained tubes, wet with the reagent, thus exposing a large absorbing surface. This reagent quickly absorbs the carbon dioxide present in the gas, one passage of the gas into the pipette generally proving sufficient. By raising and lowering the level-bottle a few times all the gas is brought into thorough contact with the absorbent, and can then be drawn back into the burette for measurement by lowering the level-bottle L, closing stop-cock E, when the reagent has ascended to its former position close to the rubber connection. After waiting one minute for the walls of the burette to drain, bring the level of the liquid in level-bottle and burette to the same height, and read the position of the lowest point of the meniscus on the scale, giving the quantity of carbon dioxide absorbed. Again pass the gas into the pipette B, return to burette, (closing stop-cock E as before) and measure, after waiting one minute for burette to drain. See if this reading corresponds to the former, to make certain that the absorption is complete. This reading, subtracted from 100, the total volume of sample gas, gives the percentage of carbon dioxide.

Determination of Oxygen. The residue, or gas remaining from the last absorption, is now passed into the second pipette C, containing potassium pyrogallate, which absorbs the oxygen. Before making the final measurement, the operation should be repeated as in the previous case, to make certain that all the oxygen is absorbed. The time required will not exceed three minutes. In making the reading first allow one minute for walls of burette to drain, this being done whenever a measurement is to be made. The reading in this case subtracted from the previous one, gives the percentage of oxygen.

Determination of Carbon Monoxide. The residue is now passed into the third pipette D, containing cuprous chloride, which absorbs the carbon monoxide. A little more time should be given to this absorption, which is somewhat uncertain; say, at least five minutes. The resulting reading, subtracted from the previous one (with potassium pyrogallate), gives the percentage of carbon monoxide.

Determination of Nitrogen. Adding the percentages of carbon dioxide, oxygen, and carbon monoxide together, and subtracting the total from 100, gives the percentage of nitrogen by difference.

Special Hints. In the foregoing operations always pass the gas into the pipettes in the order named, since potassium pyrogallate, contained by the second pipette, will absorb both oxygen and carbon dioxide; and cuprous chloride, of the third pipette, both carbon monoxide and oxygen.

Before measuring and after each absorption, wait some stated interval, making it of the same duration throughout, for the walls of the burette to drain of liquid, since otherwise the readings would be in error.

The total time required will usually be about twenty minutes for the entire analysis.

An accurate account of the cubic centimeters of absorption with each reagent should be kept, and by comparing with the absorbing capacities, one will constantly know the power of the reagent, so that he may renew it as its strength becomes taxed.

No trouble need be experienced in the use of this apparatus, even by one unfamiliar with chemical work or analysis.

To be continued.

Electro-Therapeutics

THE OLD AND THE NEW IN THEORY.

DR. ECCLES, in discussing new theories in pharmacy, points out a number of mistakes which colleges of pharmacy are making in expounding doctrines of electro-therapeutics. Those of these colleges that have not adopted new doctrines, he says, are no doubt still telling their students in chemistry that water is a good conductor of electricity, a statement now known to be false. Water is practically a non-conductor. They are probably also teaching that carbon monoxide and oxygen form an explosive mixture when an electric spark is passed through them, while the new doctrine has led to the discovery that a vapor containing hydrogen must be present.* When the so-called electrolysis of water is shown to students and it is stated that it is the water which the electricity acts upon and decomposes, they are being taught that which is not true. It is the dilute sulphuric acid which is being acted upon and electrolyzed.† When medicines like potassium bromide and alkaloids are advised to be administered in the form of elixers or alcoholic solutions, the advice is contrary to the new doctrine of electrolytic dissociation.

These are but a few of the errors that are being inculcated by those not familiar with the new doctrine, but, further, new theories show why chemical reaction goes on better in aqueous solutions than in solutions of any other liquid; why syrup is a bad conductor of electricity, and dilute mineral acids or their salts good ones ("Theoretical Chemistry," p. 309); why the osmotic pressure in dilute solutions of hydrochloric acid is twice as great as in dilute sugar solutions (*ibid.*, p. 310); why dilute solutions of sulphuric have three times as much osmotic pressure as those of sugar (*ibid.*, p. 311); why a solution of $FeCl_3$ gives an osmotic pressure four times as great as sugar (*ibid.*, p. 312); why pure water and other pure substances cannot conduct electricity (*ibid.*, p. 593); why fused salts at high temperatures become conductors (*ibid.*, p. 593); why the freezing point varies in different aqueous solutions ("Outlines of General Chemistry"); why it is generally difficult to establish chemical reactions in organic compounds ("Watt's Dictionary of Chemistry," Vol. IV, p. 184); why a solution of magnesium sulphate with sodium chloride, if evaporated at ordinary temperature, will dry out as magnesium chloride and sodium sulphate, whereas if it is evaporated at a high temperature, it dries out just as what it was when put into the solution ("Outlines of General Chemistry," Ostwald, p. 276); why iron immersed in a solution of copper salt will become coated with metallic copper ("Theoretical Chemistry," Nernst, p. 612); why solutions of salts conduct electricity and solutions of many organic compounds do not ("Watt's Dictionary of Chemistry," Vol. IV, p. 191).

These examples probably suffice to show something of the scope of the light shed by the new theory. Only a beginning has been made in this direction, but it is quite promising.

ONE CANDLE-POWER PER WATT.

The similarity of materials used in the Nernst electric lamp and those used in the Welsbach mantle is well known, and now the English electrical papers call attention to a new electric incandescent lamp designed by C. Stearn, of the Zürich Electric Lamp Company, in which a mantle of refractory oxides is rendered incandescent by means of a discharge on to it of cathode rays. Mr. Stearn claims a lighting efficiency of one candle-power for every watt of energy expended.

C. S. KNIGHT, one of the best known men in the electrical fraternity, and late vice-president of the Fort Wayne Electric Corporation, has been elected vice-president and general manager of the Siemens-Halske Company of America, and has entered upon his new duties in the general offices of the company in the Monadnock Building, Chicago.

---

*"Theoretical Chemistry," Nernst-Palmer, page 575.

†"Watt's Dictionary," Vol. IV, page 177.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity and Transmission of Power.

Official Organ of the Pacific Coast Electric Transmission Association.

Subscription invariably payable in advance. Terms—Domestic, One Dollar per Year; Foreign, Two Dollars per Year. The trade supplied by the San Francisco News Company. Advertising rates furnished on application.

GEO. P. LOW, : : : Editor and Proprietor

PUBLICATION OFFICE:
320 CALIFORNIA STREET,
ROOM 14.

Address all communications to
Editorial rooms, 427 TENTH AVE.
Telephone, "Steiner 627."

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME VII APRIL, 1899 NUMBER 4

EDITORIAL.

"FOOLS RUSH IN WHERE ANGELS FEAR TO TREAD."

Of the competition which exists in the gas business there is little to be said at present, but most of that little has been well said in a late number of the *San Francisco News Letter*, which expressed the sentiments of two-thirds of the business public of the Western metropolis when, in discussing the first annual report of the Equitable Gas Light Company, it pointed out that on February 21, 1899, the Equitable company had issued 170,500 shares of stock, which netted $190,010, or about $1.11 per share. In February last this stock sold on the board of the San Francisco Stock and Bond Exchange at $12 per share, making a profit over the amount paid in of about 1000 per cent. About 62,000 shares were sold to the Central Light and Power Company for the sum of $25,000, averaging about 40 cents per share, which stock has, within sixty days, been distributed to stockholders in the way of a dividend. Those gentlemen who received this dividend and sold their stock at $12 per share, made a trifle less than the marvelous profit of 3000 per cent. The secretary's report shows that the balance of assets on February 21st was $190,256.16, showing an apparent gain during the year of $246, but where it could have come from the report does not state. The company began delivering gas some time early in January, and up to the 21st of February, according to the same report, the total receipts from all sources other than from the sales of stock, were but $246.16. At the present market price of say, $9.00 per share, the property of the Equitable company is rated by buyers in the exchanges at something like $1,530,000, truly a magnificent increase over the sum mentioned by the secretary of $190,256.16, as being the balance of the assets of the company.

"There must certainly come a day of reckoning," continues the *News Letter*, "for those parties who are buying at this price, for, according to the latest information, the company, although having furnished gas for a period of about ninety days, and having laid a great many mains and made much newspaper talk, has still less than 130 consumers. It seems wonderful that the public is not more familiar with these facts, but we suppose it will not believe them until it finds out that it can only sell for about ten cents on the dollar what it has paid out its hard earned money for. It must be admitted that a company that can sell stock at 1000 per cent. profit need have little concern for its earnings."

On the other hand, the investor must look with only satisfaction upon the placid amicability of the relations that have for years existed between the gas interests of the San Francisco Gas and Electric Company and those of the Pacific Gas Improvement Company. They have uniform rates, do business according to uniform methods, and neither company trespasses beyond its agreed territorial bounds. Each makes gas according to its own ideas, their plants are entirely independent, and so harmonious are the relations between the two corporations that, so far as the public is concerned, they might better be under one roof, as are their gas stove departments even now. Indeed, it is probable that if the investor had his choice, he would have consolidation at once, and be done with divided operating and executive costs; but longer heads than his see the greater wisdom of the belief that in actual union there is weakness, in ostensible competition there is strength: for capitalistic San Francisco has learned well that true competition is the thief of dividends, even though the life of monetary trade.

EVOLUTION, NOT REVOLUTION, IS AT HAND.

The word of admonition given by Alexander Siemens to the Society of Arts at the conclusion of the discussion of the paper by James Swinburn on the Nernst lamp has found unexpected endorsement. It seems that the exploiters of the Nernst patents have issued a prospectus before the English public inviting applications for £115,000 in 7 per cent. non-cumulative shares of which the vendors take £90,000, in addition to the whole of the ordinary share capital of £180,000. Commenting on this a London contemporary states that this seems a high price to pay for an invention which is in an experimental stage, especially when it is remembered that the countries for which the company secured patent rights (not yet granted in most cases) do not include any European country, North America, or Canada. The prospectus further says that the greater part of the European rights for the new lamp are controlled by the Allgemeine Electricitaets Gesellschaft, but it does not tell that this company, in its last report, said that "it is not expected that the Nernst lamp will displace to any great extent the ordinary glow lamp," nor does it tell that the sum the Berlin company paid for the German patents has already been written off.

Evidently the principal electrical manufacturing company of Germany can discern no revolutionizing feature in the Nernst invention, despite the claims that it possesses the remarkably high lighting efficiency of 1.5 watts per candle-power.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

MINING IS ITS ELEMENT.

A prominent western mining journal which has coupled an electrical clause to its headline, makes an astonishing misstatement in a recent issue concerning one of the fundamental laws of electricity. The contemporary states:

> The transmission of electric energy is subject to the same laws of resistance as gases. When a powerful electric current is transmitted through a conductor, if it be desired to reduce the resistance, the voltage or electric pressure is increased; as the higher the voltage, the lower the resistance, and, conversely, the higher the amperage or electric quantity, the greater the resistance. A statement that includes electrical transmission and the transmission of fluids may thus be made: The resistances vary inversely as the pressures, and directly as the losses.

Electricians will be quick to recognize the ridiculousness of the above interpretation of Ohm's law, but charity to the layman calls for a statement that will disabuse his mind of the false notions there given. After boiling it down, sifting it out, and seasoning it with the veriest rudiments of electricity, (for the excerpt given obviously purports to be naught else) it is believed that what our contemporary intended to say was that the transmission of electric energy by direct currents is subject to laws not unlike those which determine the losses in pressure resulting from the transmission of gases through pipes. When a given amount of electrical energy is to be transmitted through a conductor, if it be desired to reduce the losses consequent thereto without increasing the size of the conductor, the voltage is increased; as the higher the voltage, the lower the line loss or drop in voltage resulting from the transmission. Conversely, the higher the amperage, the greater the loss under the given condition.

It may be added that amperage does not express "electric quantity;" it is the term used to denote the *rate of flow*, and, as such, is analogous to miners inches. "Electric quantity" is expressed in coulombs, and, as such, is analogous to gallons.

There is to be no charge to our otherwise valued contemporary for this tutelage.

* * *

THE "WORLD" AND "ENGINEER" COMBINED.

The surprise of the year in technical journalism has been the combination that has been effected between *The Electrical World* and *The Electrical Engineer*, by which the two leading electrical journals of America will henceforth appear as *Electrical World and Electrical Engineer*, under the editorship of T. Commerford Martin and W. D. Weaver, and the business management of James M. Wakeman, late of the *American Machinest*, and A. C. Shaw. There are none in electrical journalism whose abilities are more universally recognized or more highly esteemed than those of Messrs. Martin and Weaver, and it is but mild endorsement to say that America's leading weekly electrical publication could not possibly be in better editorial hands. Equally true is it that the electrical public will feel keenly the loss of the writings of Joseph Wetzlar, late co-editor of *The Electrical Engineer* with Mr. Martin, and who, in a farewell editorial note in the last issue of that journal, announces that hereafter he will devote himself entirely to The Electrical Engineer Institute of Correspondence Instruction. Similarly too, W. J. Johnston, proprietor of *The Electrical World* since its inception twenty-five years ago, announces his retirement from electrical journalism, and in doing so he should certainly feel proud satisfaction in the realization that his labors have builded the most influential electrical periodical the world has ever known. The consolidation was effected through James H. McGraw, of the *Street Railway Journal*, and his associates.

* * *

INEFFICIENCY OF INCANDESCENT LAMPS.

Judging by the criticisms received, there are many who have read with considerable surprise the assertions appearing in these columns concerning the woeful inefficiency of the incandescent electric lamp as a light-giving agency, in view of which it may be well to publish the confirmatory opinion of Gilbert S. Ram, in his valuable work on "The Incandescent Lamp and Its Manufacture," where, on pages 210 and 211, he states: "At a temperature of four watts per candle-power, it has been estimated by actual experiment, that the proportion of luminous radiation in an incandescent lamp is about five per cent. only, while the proportion in the case of an arc lamp is about ten per cent. . . . . . The ideal lamp is one from which the radiation is wholly luminous. The carbon incandescent lamp is, therefore, very far indeed from attaining the ideal standard. A more efficient lamp must be looked for in another direction."

* * *

A GENERAL FORMULA FOR TRAIN RESISTANCE.

A new general formula for train resistance, with diagrams and a table showing the closeness with which the results obtained thereby agree with actual tests, is given in an editorial appearing in the *Street Railway Journal*, February issue, and the digestion of this editorial by all who are interested, is commended.

The formula, which is due to John Lundie, consulting engineer of the South Side Elevated Electric Railway, is as follows:

$$R=4+S\left(0.2+\frac{14}{35+T}\right)$$

where

T=the weight of the transportation unit in tons (2000 pounds).

R=resistance in pounds per ton.

S=speed in miles per hour.

The publication quoted endorses the formula as appearing to be applicable to "*passenger* trains of all weights, running at all speeds up to the highest limit so far reached," and describes that Mr. Lundie's method of determining train resistance is based on an examination of the speed curves of a train when coasting from any speed to a dead stop. It does not check the most recently obtained data for exceedingly heavy freight trains.

Gas

THE WESTINGHOUSE GAS ENGINE.*

BY EDWIN RUUD.

GAS engine engineering is a peculiar and difficult line, probably one of the hardest branches in the entire mechanical field of today. This you will understand when you stop to consider that the temperature in the cylinder during the explosion periods is a dazzling white heat, and that many parts are exposed to this high temperature. Add to this the different behavior of the various kinds of gases, and that the whole process is going on within closed doors, so to speak, where you have very little chance to see what is taking place, and you can imagine the difficulties of the problem. It is a wonder that an engine can be made to run satisfactorily under such conditions. It requires a constant association with the subject in order to fully understand and to be able to overcome the numerous difficulties which present themselves. The difficulties increase with the size of the engine, due to the fact that the heat problem becomes more and more troublesome to solve. It is for this reason that the gas engine has not made much headway in the larger sizes. Also, few men have been willing to experiment in large sizes of gas engines, in view of the uncertainty and the abnormally heavy expense connected with the development of, say, a 1000 horse-power gas engine. I shall later on say a few words touching upon large-size gas engines.

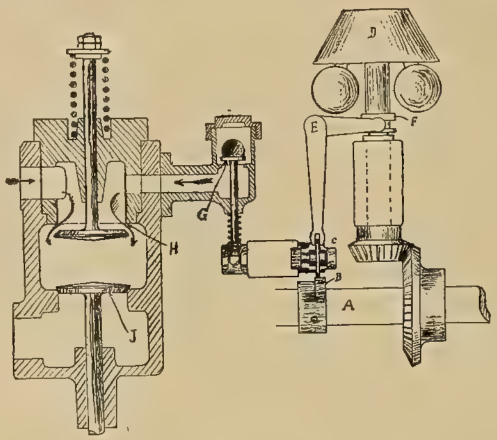


FIGURE 1.

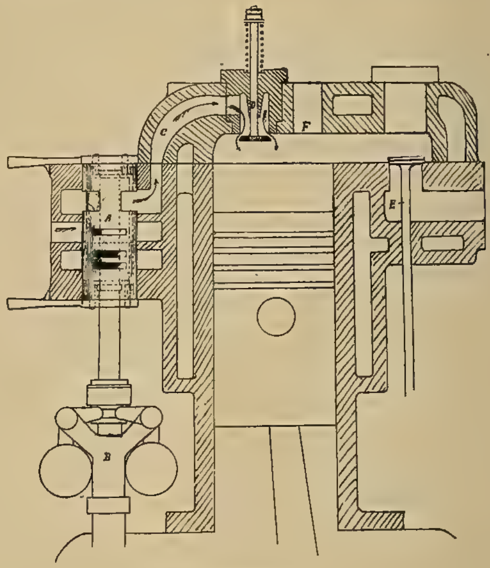


FIGURE 2.

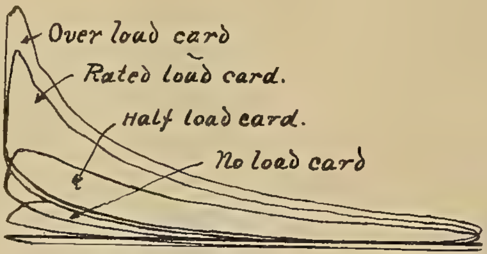


FIGURE 5.

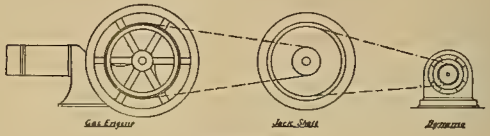


FIGURE 3.

I shall, in the course of this short talk, confine myself to two classes of engines now in use, and shall endeavor to explain or make clear to you the workings of these two kinds of prime movers. This classification is made with regard to the mode of regulation, the cycle being the same in both the "Otto" or "Beau de Rochas;" in fact, this cycle is about the only one used today commercially. I shall try to point out the advantages and the disadvantages of these two classes in order. But before I do this, I shall explain the working or principle of the gas engine in general for the benefit of the members who may not be familiar with the underlying principle. (Here the lecturer made some sketches on the blackboard and explained the first principles of design in the gas engine.) The so-called "hit-and-miss" gas engine has been made exclusively until recently, and I shall therefore describe this style first.

The phrase "hit-and-miss" is admirably well adapted for this type, as you will see.

Figures 1 and 2 illustrate the principles involved in this mode of governing.

The cam shaft *A*, Figure 1, which operates the exhaust valve *J* and other parts, runs only half the number of turns that the engine does. On this shaft is fastened the cam *B*, which moves the gas valve *G* when the roller *C* is brought in the proper position so as to ride on the cam. The governor *D* controls the position of this roller by aid of the bell crank lever *E*. Thus, if the speed of the engine is too low, the governor balls will ride closer to the spindle, and this will raise the governor sleeve *F*, thus operating the lever, which moves the roller *C* on its spindle to a position where the cam will strike it, raising gas valve *G* and permitting the gas to be drawn to the inlet valve *H*, where it mixes with the air as it enters the cylinder of the engine. On the return stroke of the piston the charge is compressed and ignited at dead center. Now comes the expansion stroke and then the exhaust valve *J* is opened, and on the return stroke the products of combustion are expelled.

You will see that by this mode of governing one or more charges may be cut out, and that the engine either takes in a full charge of gas and air or omits the gas altogether, as the gas valve stem is only in position to be operated by cam *B* when the engine is running at or below normal speed.

Thus you will readily understand why the "hit-and-miss" type of engine is not suitable where a uniform speed is required, and but few of this type are running in connection with dynamos for lighting purposes. Where they are driving dynamos it is generally done as indicated in Figure 3.

As Figure 3 shows, the gas engine is belted to the pulley on the jack-shaft and from this in turn to the dynamo.

The "hit-and-miss" gas engine must have heavy fly-wheels, and a heavy balance wheel is usually mounted on the jack-shaft in order to obtain an approximately steady speed. I have even seen some outfits of this kind having a small fly-wheel on the armature shaft. This arrangement, as you will see, takes up a great deal of floor space. The flapping of the engine belt, due to the irregular motion of the gas engine, together with the ordinary hissing sound from the two belts, makes the plant a very noisy one. The variation in the voltage on a 100-volt circuit is generally 3½ to 4 volts during the cycle. That is, when the engine may take in a few charges successively the voltage is steady and rising, but when the engine omits one or more charges a momentary variation in speed is the result, and fluctuation is apparent in the lights.

This introduction of two extra belts, shafting, and masses to move causes quite a loss in power. The power absorbed by the two belts will be approximately seven per cent., and by the jack-shaft about three per cent., making a total of about ten per cent. taken up by the extra machinery. Even with this auxiliary machinery the speed of the dynamo is unstable and the service unsatisfactory. This type of engine is, therefore, limited to do work where steady speed is not necessary or required. This type of engine has one advantageous feature, namely, that the charge is always ignited under the same pressure, and hence the actual work done by the exploding gases in a given cycle is practically the same for full load as for no load.

---

*Address before the Technischer Verein (Technical Society) of Pittsburg, Pa.

Recent developments have proved that the modern type of gas engine is admirably adapted for electric lighting, as its economy is very high, and its speed regulation in a type to which I shall refer has been made as good as that of a first-class steam engine. It is the electric business which has stimulated the experiments in the direction of producing a gas engine which would be suitable for incandescent lighting work. It is in contrast to the "hit-and-miss" type that I show you illustrations (Figures 2 and 4) of gas engines having the armature on the crank-shaft, direct-coupled, or directly-belted, precisely as its brother, the steam engine.

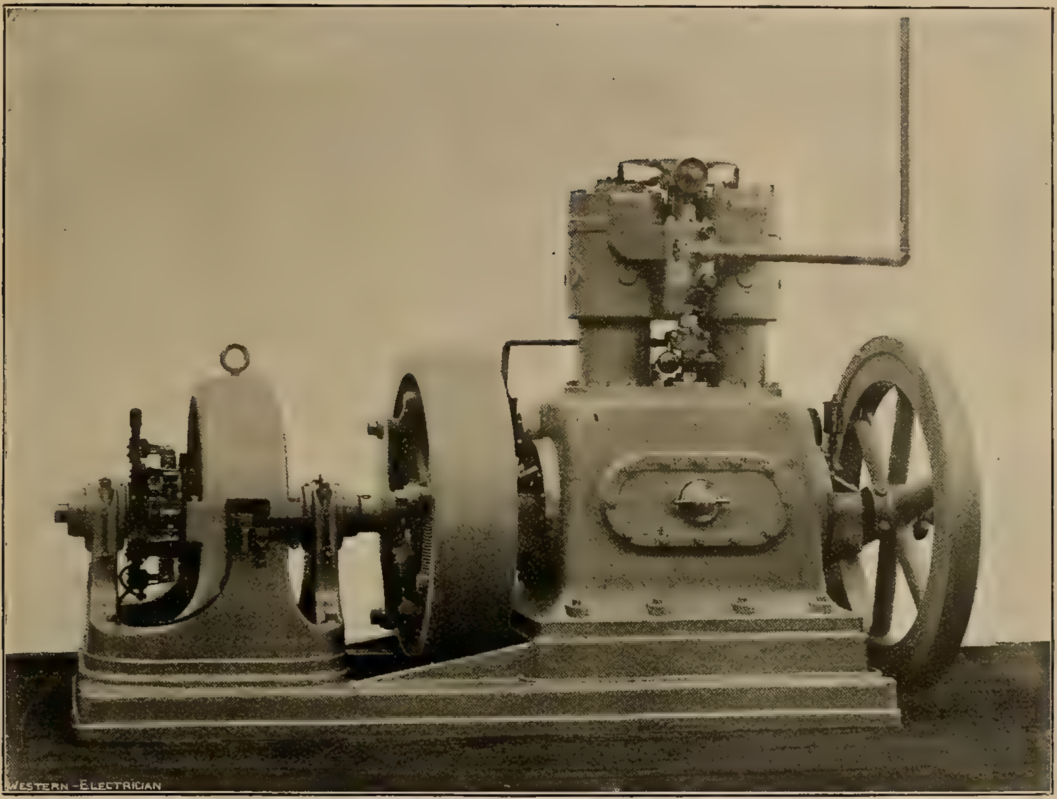


FIGURE 4.·THE WESTINGHOUSE GAS ENGINE.

Figure 2 illustrates a gas engine cylinder and mixing valve of the type which proportions the charge in accordance with the load. The gas and air are mixed in the cylindrical mixing valve *A* in the proper proportions at which the same is set. This ingenious device is in reality a proportional meter, and preserves the proportions between the gas and air whether the engine runs at no load or full load. Thus the governor *B*, in connection with this valve, has absolute control over the amount of explosive mixture to be taken into the cylinder through channel *C* and inlet valve *D*. The charges are ignited by an electric igniter, located at *F*. This igniter, which is fully patented by the Westinghouse Machine Company, differs from all other igniters in the respect that it is duplex and the bonnet covers two separate mechanisms. This construction makes it possible to change the connections of the wire from the battery to either set of terminals while the engine is running. If desired, both sets of terminals can be used at one time, thus insuring absolute certainty of ignition. This is often done in large electric station work.

From this you will see that the last-described mode of governing is similar to that of the steam engine, and that for picking up a heavy load it is even in a better position. All charges being proportioned to the load, if the load is suddenly thrown off there is one heavy charge already locked in, which cannot be removed, although the governor acts instantly, and there may be another under way which may be partially reduced by the action of the governor. This tends to speed up the engine a trifle above the normal, but because of the fly-wheels this tendency is so slight that it can be ignored in practice; besides there are very few plants subjected to throwing off the entire load at once. Having described both classes, I shall now dwell upon the gas consumption, and what I say in this respect is applicable only to the Westinghouse gas engine.

GAS CONSUMPTION.

The gas consumption in all engines varies with the kind of gas used and also with the size of engine up to certain limits. The average performance of the Westinghouse gas engine, say from 20 horse-power upward, is 10.5 to 12 cubic feet of natural gas per brake horse-power hour. According to numerous tests with the Junker calorimeter, I have found that the average heat value of natural gas is 1000 British thermal units per cubic foot. That is, the engine requires 10,500 to 12,000 British thermal units for each brake horse-power hour, giving a heat efficiency at the shaft of 25.4 per cent. and 21.3 per cent. respectively. The above are not fancy figures, but represent the everyday performance of the engines while in the hands of the customer.

The indicator cards taken from a Westinghouse gas engine will give the reader an excellent idea of the governing action under overload, rated load, half load, and no load. (See Figure 5.)

Some special engines have been built which have given much better results than the above mentioned, and I have in mind a special 125 brake horse-power gas engine which, when tested, gave the phenomenal economy of nine cubic feet per brake horse-power. This would give an efficiency at the shaft of 28.7 per cent.

These are good results, but they are not as good as may be expected, and I firmly believe that the everyday performance of a gas engine will, within a short time, reach 33⅓ per cent. Some experiments are being made along this line now, and with reasonable show of success. In comparison with this result I quote the gas consumption of the Lenoir engine of 1861, which was practically 90 cubic feet of about 700 heat unit gas per brake horse-power hour. This engine was really the first commercial engine offered to the public. The next step was the Otto-Langen free-piston engine, which in reality was the invention of Barsanti and Mattencci, brought out in or about 1867. According to Tresca, the gas consumption per brake horse-power was 44 cubic feet per hour. In 1876 Otto brought out the so-called "Otto Silent" gas engine. This engine was a compression engine, and in principle not very different from the "hit-and-miss" engine of today. This cycle is called Beau de Rochas, or the Otto cycle, although Gustav Schmidt is probably the originator of it. The consumption of gas was about 30 cubic feet per brake horse-power hour. Thus we can see that the efficiency of gas engines has been notably improved.

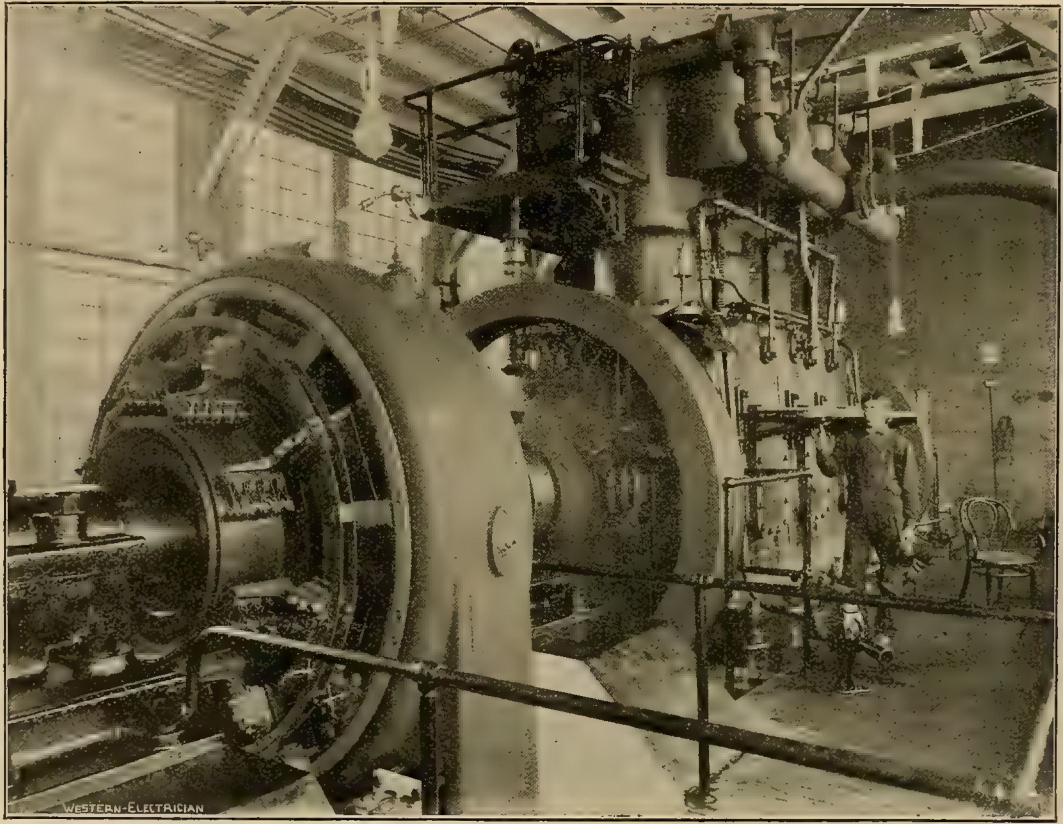


FIGURE 6.—LARGEST GAS ENGINE IN COMMERCIAL OPERATION.

WATER CONSUMPTION.

It is necessary in a gas engine to have the cylinders and all the parts exposed to the heated gases water-cooled, in order to prevent over heating of the different parts. This is generally done by letting a stream of water flow through cylinder jackets. As the public at large seems to be ignorant as to the water consumed per brake horse-power hour, I shall here state the amount of water required. In winter the consumption of water may be put down at about 30 pounds, and in summer 38 to 40 pounds per brake horse-power. In places where water is expensive, this need not be wasted, as by putting up a tank or tanks, according to the size of the engine, the loss of water need not be more than a few gallons per week, or just as much as the evaporation of water from the surfaces of the tanks would amount to. Another way of cooling is by the use of a cooling tower. The water is pumped from a well through the water jackets of the gas engine cylinder, where it becomes heated, and from there over to the top of the cooling tower, to again return to the well at about atmospheric temperature, to be used over and over. This mode of cooling produces a greater loss of water than that of the tank system, but it is almost always used in connection with large sized engines. Not long ago I made some tests for the purpose of determining the amount of water necessary for cooling and to determine the heat lost through the same. It was found that 5121 British thermal units went out in the cooling water, 2922 British thermal units were converted into work, and 2957 British thermal units must then be the approximate amount of heat which went out through the exhaust and was lost by radiation. From this you will see that there is still room for improvement toward efficiency. The bulk of the loss is in the cooling water.

FUTURE OF THE GAS ENGINE.

Until recently the gas engine has been made in comparatively small sizes only, and, as I have before stated, only for what you may call rough work, that is, where steadiness of speed was not essential. The largest engine in this country, made commercially, was only 100 horse-power, having two cylinders and of the "hit-and-miss" type. The public looked upon the gas engine as a sort of "freak," and did not take very kindly to it. The hard times, however, which we have experienced during the last five years or so have done much toward introducing the gas engine. The keen competition and the small margin of profit caused manufacturers and business men to look around for some spot where a saving could be effected in their establishments. An investigation followed which was favorable to the gas engine. The introduction of electricity, calling for prime movers, also stimulated the demand for a cheap and convenient motor, and this, more than anything else, has brought the gas engine forward. When Mr. Westinghouse, about five years ago, commenced experiments in the gas engine field, he did so because he foresaw a large future demand for the gas engine in the electrical field, if it could be made to give the service that its brother, the steam engine, was doing. Experiments on a fairly large scale followed, both on compound and single expansion engines. The work was hard and trying, as the obstacles to overcome were numerous, but the results have been gratifying. In the early part of the spring of 1898 an engine of about 650 brake horse-power was completed in the works of the Westinghouse Machine Company. (Figure 6 illustrates this engine operating a direct current, 500-volt engine-type generator.) This engine is of the three-cylinder type and has a speed of 150 revolutions per minute. After it was thoroughly tested on the testing foundation, it was erected in the power house of the Westinghouse company, where it is running in regular commercial service of a severe character.

The engine is direct-connected to a suitable generator and runs in conjunction with one or two steam engines, according to the call on these units for electric current. This engine is by far the largest gas engine in the world, and it is pleasing to record that this large gas engine was built in Pittsburg. But this engine will not long enjoy the distinction of being the largest one. The Westinghouse company is making drawings and patterns for a 1500 brake horse-power gas engine. This engine is also of the three-cylinder type, and it is designed to run at 100 revolutions per minute. Remarkable economy is expected from this engine, as every possible care is being taken to make it a model of modern gas engine engineering. It would not be surprising if this engine developed a brake horse-power for every 8½ cubic feet of natural gas consumed per hour, or 8500 British thermal units per brake horse-power hour. This would give a heat efficiency of $\frac{2564}{8500}$ or 30 per cent. at the shaft. When gas engines can be made of such efficiency in large units, they will undoubtedly compete successfully with the most modern steam engine.

A gas engine of such size and efficiency will run day in and day out on less than one pound of coal burned in a good produce gas plant per brake horse-power hour. This includes banking of fires and the like losses. It would have to be a high-grade steam engine and boiler plant if it should regularly be able to produce a brake horse-power for two pounds of coal per brake horse-power hour, twice the amount of fuel required by the gas engine under similar conditions. From the foregoing you will see that the gas engine is no longer limited to special power purposes. It can hold its own as a prime mover, and can be used for almost all purposes for which the steam engine can be used. But all this has not been accomplished in a day. It is now 108 years since the first patent on an explosive motor was taken out by John Barber, and from that time on it may be seen that great improvements have been made.—*Western Electrician.*

NO STANDARD OF ILLUMINATION.

It is a singular fact that there is absolutely no standard or unit of illumination. An architect or engineer confronted with the problem of lighting an interior, for example, with whatever sort of illumination, has no more reliable criterion to guide him than common experience. His methods of solution will inevitably resolve itself into guess work. He does not know what intensity of light he wishes to attain, and if he did he would not know how to set about procuring it. Heating and ventilation have been reduced to fairly exact sciences in which, at least, there are degrees of intensity and units of measurement; but there is nothing tangible about lighting. The prevailing rule seems to be that a little more than enough light is just about right.—*The Engineering Magazine,* Vol. XVI, No. 6, page 1004.

ELECTROPLATING PREVENTS FOULING OF HULLS.

The electroplating of the hulls of iron ships has been favorably reported upon by officers of the United States Navy Department who state that the hull of the vessel under test was plated with copper in February, 1895, and has been in continuous use since without necessity for cleaning. A current rate of 7½ amperes per square foot, and a difference of potential of 1½ volts are sufficient to deposit a perfectly uniform, smooth, adherent coating.

Illumination

THE LESSON OF A MUNICIPAL FAILURE.*

BY J. H. STALLARD, M. B., LONDON, ETC.

THE facts relating to the lease of the Philadelphia Gas Works have been fully stated and sufficiently discussed by several distinguished writers, but as yet no one has touched upon the real cause of failure or proposed a remedy.

The great advantage of the municipal ownership and operation of gas works can not be disputed, and it is a most lamentable circumstance that the third largest city in the United States, after ten years' experience, has relinquished their control. In spite of all possible explanations, such action must be regarded as a confession of inability to administer them successfully, and an acknowledgment of the superiority of private over public management. This unfortunate conclusion cannot be ignored, and certainly ought to lead to a careful contrast of the two systems, in order to find out wherein they differ, and whether there is any hope of putting municipal gas-work management and the conduct of other public utilities on a private corporation basis. If this could be done, we might reasonably expect the same result.

In the first place, it must be noted that the citizens substantially correspond with the stockholders in a private corporation. In both cases the stockholders may be few or many, male or female, old or young, wise or ignorant, rich or poor. All or none may be endowed with social or philanthropic instincts. Like private stockholders, citizens may constitute a strange and constantly changing medley of Protestants, Catholics, Atheists, Socialists, Democrats, Republicans, Populists, etc. Neither "private" nor "citizen" stockholders expect personal association in the conduct of affairs, but are ready to intrust their interests to their representatives. The main difference consists in the need of residence. Whilst the private stockholder may reside in London, Paris, or Japan, the citizen acquires his interest by residence, and at the same time becomes the consumer of his own productions.

In the next place, the success of corporations is not dependent on the character or social standing of the stockholders, but on the form and constitution of the business government. No large business corporation trusts the management to a single person except when that person owns the controlling interest and would be the greatest sufferer by his own neglect. The very worst proprietary is certain to prefer the election of honest representatives. Whilst the efforts of the most exemplary and most honorable body of stockholders and officials would assuredly fail if the principle of management encouraged the growth of corrupting human weaknesses. Under such conditions the most immaculate officials must eventually become corrupt. From this it follows that corruption in government affords *prima facie* evidence that its form and method must be wrong.

How, then, do private stockholders secure honest and successful management? It is universally acknowledged that there are no two ways. They simply elect a committee of themselves. They elect a corporate body, which they endow with corporate power and corporate responsibility; which determines the policies and the mode of action; which appoints, promotes, and removes all executive officers at its own pleasure, settles their salaries and duties, and the conditions of all employment; which supervises all official acts, regulates all expenditutres, orders all repairs, improvements, and extension of the works, and asks of the stockholders more capital as soon as it may be wisely and profitably employed.

This representative board of directors has absolute and undivided control. No one is permitted to obstruct their deliberations or dispute their action. No one can veto their ordinances nor contract their operations. No one can cancel or postpone the payment of their checks. In the election of a corporate business management, individual power and responsibility are both lost. No individual can have special privileges by right. No one has

---

*From *The Overland,* February, 1899.

personal power to give an order, make an appointment, remove an official, or spend a cent, without the elected corporate consent. No one has it in his power to promise appointments, contracts or emoluments of any kind, to the friends who have assisted to elect him. No one has "spoils" to give away. Moreover, the board of directors is not permitted to alienate any portion of their power to boards, commissioners, or individuals, over whom they have no absolute control. They are responsible for the fitness and conduct of every officer employed, and can not shift any part of the appointing, promoting, or controlling power on the shoulders of commissioners less qualified than themselves to judge of the merits of the candidates or their special fitness for the duties they are expected to perform. And lastly, the sole and most efficient bond of union is the financial interest of the corporation, and the sole test of success is the profitable return.

If these simple conditions satisfy the requirements of a private corporation, why should they not be tried in city government and in the management of public gas works?

Now, it is remarkable that no successful municipal government can anywhere be found which is not conducted on this simple business plan, and municipal authorities so constituted present innumerable examples of the successful management of gas works. The town of Birmingham, England, is a case in point. It is a large manufacturing town which, like Philadelphia, is engaged in a variety of industries. There are 95,000 citizens who vote, or nearly one-fifth of the population, a proportion equal to that of an American city. The large council elected by the city has complete control; the gas works are managed by a committee of eight members, who submit all their operations for the approval of the council. Their last report presents a sample of their work. They state that additional and enlarged mains are required in districts in which it was found difficult to maintain the supply as efficiently as necessary for gas engines and heating purposes. They report that a bench of retorts had to be reconstructed, and that the adoption of eight instead of seven retorts will require a small expenditure on capital account. They report the acceptance of tenders in connection with the works, and that satisfactory terms have been arranged with patentees for the use of inclined retorts. At the request of the council, they have made arrangements for providing a recreation ground from a portion of land not in present use, and are in communication with the baths and parks committee, who will carry out the scheme. The committee has under consideration a revision of the salaries rendered necessary by more important duties, and in answer to an application from one of the superintendents for an increased salary, they propose to grant him an addition of $250 a year. Their accounts show a profit amounting to more than a quarter of a million dollars. This profit is dealt with in a purely business way. The committee reports that half of the total output is sold to consumers whose demands remain constant throughout the year, and whose consumption it is most desirable to encourage. They report that some of these large consumers are providing themselves with gas-producing plants, and that the price to this class must be reduced to arrest this loss. They therefore request that a reduction of twenty per cent. below the highest price should be made to them. They also recommend that the charge for gas for public lighting be proportionately reduced. They estimate the gross cost of these reductions at $150,000 yearly, which will, it is hoped, be recovered by increased output. It is an error to suppose that the management is authorized to favor any special class, or to set aside financial considerations for the sake of social or industrial progress. They put in connections and fixtures as a pure matter of business to promote gas consumption. They introduce penny-in-the-slot machines to extend the use of gas amongst classes who are unable to use it on any other terms; they rent out gas stoves to those only who cannot afford to buy them; and in order to meet the financial conditions, they raise the price to all these small consumers.

Throughout the report of the committee there is no mention of the manager, who is not permitted to share in any part of their responsibility. He is simply the servant who is paid for his technical skill, his advice, and his executive ability. For the due exercise of these he is immediately responsible, and would be discharged for failure. He recommends candidates for employment, but cannot appoint them. He recommends the purchase of materials, but has no power to order them. He proposes new processes, but cannot introduce them, and new machinery of production without the power to construct it. Thus is the power of the executive kept under corporate control, and the separation between legislative and executive functions made complete. From this example, which is one of hundreds, it becomes evident that the same form of business management which is found in private business corporations will surely succeed in the management of public utilities under municipal control.

If we examine the municipal governments in American cities, we find that all the characteristic features of private corporation management have completely disappeared. Corporate wisdom is no longer regarded as the test of safety. Corporate power is overwhelmed by individual power. Corporate responsibility is despised, and is replaced by that of individuals. And all this in spite of the accepted principle of all good government, which affirms that no individual action can possibly replace the concerted action of the people, who are necessarily most interested in successful government.

It is discretionary individual power which is the source of every kind of abuse and destroys responsibility. It is therefore one of the first duties of a business government to define its limits, and the duty can never be left to the judgment of a single man. No nation can be properly governed by a king or emperor, and all great business corporations are conducted by corporate authority. The government of the complicated activities now demanded by the citizens assuredly belong to this category, and must therefore be intrusted to representative corporate control.*

No capitalist would venture to invest his savings in a gas works with a management constructed on the lines of the Philadelphia government. Instead of a body of representative directors, upon whose corporate wisdom and honesty he has been accustomed to rely, and to which as a body, and not to any individual, he has given unlimited and undivided power over the company's affairs, he finds an emasculated creation, falsely dignified with the name of council, which has been constructed under the power of an immutable charter, from which there is no possible escape, and which curtails freedom of action in every possible direction. Unlike the construction of a private business corporation, the charter of Philadelphia forbids the council to appoint the president or mayor, who is elected by the people, not as the servant of the council, but as its master. This official is an ingenious complication of legislative and executive power. As official chairman of the council, he is the head of the legislative body, and in this capacity he largely controls the course of business and the subjects of deliberation. Without his assistance there can be no budget. He must approve of all appropriations. His consent is specifically required to complete every act of legislation; and above all he exercises the power of the veto, which is alone sufficient to modify the whole course of legislation and expenditure. Short of giving him imperial authority, it seems impossible to confer more legislative power upon a single man. But besides this, the charter makes the mayor the central figure of the executive. He appoints the heads of the six departments who form his cabinet and are supposed to be responsible for the conduct of the gas works. Here, then, we have in the person of the mayor that intimate combination of legislative and executive power which is denounced by the Hon. Seth A. Low and every statesman in the world. The logical conclusion is that one or the other of these functions must be given up. If the mayor is still to be the executive center, he should be retired from the council, like the President of the United States, and if he remain a councilor, he should be relieved of his executive functions. In a private business corporation the president is simply chairman of the council, and exercises no ex-

---

*See *The Overland*, March, 1897.

ecutive functions without their approval and authority. To get a business management in Philaelphia, it will be necessary to destroy the power of the mayor.

In the next place, the investing capitalist would be astounded to find that the elected corporate body cannot be trusted to appoint the gas works manager. In Philadelphia the mayor appoints a director of public works, who in turn appoints the chief of the gas works. ' The chief of the gas works again in turn appoints an army of deputies, superintendents, mechanics, clerks, coal-heavers and other workmen. He spends more than a million annually in salaries and wages, and is thus enabled to barter the appointments with the individual councilors to attain higher wages and more appropriations for his henchmen, and with outside political bosses for the electoral support of his patrons. Thus is created one of the most powerful political machines to be found outside of Tammany. In all these arrangments the corporate power of the council is utterly ignored. The manager of the Philadelphia gas works is in fact the boss. The council are supposed to be utterly ignorant of gas making. The corporate wisdom of the council is not in it. The council does not determine the policies of action. It does not appoint the engineer and chemist, or settle the kind and quality of gas, the mode of manufacture, or the nature and cost of the machinery. None of the thousand practical questions which are submitted to and determined by the equally ignorant business directors of a private gas corporation are submitted to the council of Philadelphia. The council has no practical interest in the management, and no real responsibility. No wonder, therefore, that it seizes upon all seeming profits, not with the object of providing for depreciation or extension of the works, to meet the demands of the increasing population, but to promote the false policy of currying favor with the customers, by reducing the price of gas and the taxes of the citizens. But the charter interference with the management does not end here. The charter provides for the separate election of an auditor, with powers nowhere to be found in any private corporation. Business and English municipal auditors examine the books and compare them with the vouchers and cash balances, and report the result to the council and the public. But American municipal auditors, whilst they would be compelled to sign the account of a contractor charging double prices by order of the council, or on the demand of a gas works manager, who secretly receives whisky and jewelry in the place of coal, are obliged to examine every bill presented by the council and sign it before it can be paid. The poor council can not be permitted to sign its own honorable checks without the assistance and approval of the auditor.

Again, who ever heard of directors of a private corporation not trusted with the care of cash? No such official as an elected treasurer is to be found anywhere in the whole world outside of an American city government.

The same remark applies to the tax collector, or chief clerk, and recorder. Corresponding officials are all appointed by the directors of a private corporation, and are removable at their pleasure. All municipal officials in America are endowed with discretionary and executive power. Indeed, the admixture of the two is adopted as the principle in the New York charter. "Whenever," said the charter-makers, "the work of the department is principally discretionary (legislative), a board has been provided, and whenever a department is chiefly executive, a single commissioner has been provided." This discretionary power enables both boards and individuals to take care of their relatives, friends, and political acquaintances, and subjects the best-intentioned and most honorable men to "pulls" and other evil influences, which make official life repugnant to them, and turns it over to the venal and corrupt.

It seems that an angelic constituency would be unable to secure the successful management of gas works or any other public utility with such machinery of government; and that it is simply absurd to put the blame of failure on the absence of social ideals or the want of public spirit of the citizens. The citizens of America are better instructed on public questions than any in the world, and take a more active interest in what is going on. Public opinion is both sound and strong, and if it could have acted, the existing municipal institutions of America would have been swept away long ago. From a long acquaintance with the cities of England, and a residence in San Francisco of a quarter of a century, I can testify that the citizens of all large cities are substantially the same in character, and that in all there is a crowd of honest citizens ready and willing to give their time and services in the honorable service of the public. But the essential condition is that they shall be elected and treated as trustworthy and honorable men, no law being adequate for the control of rogues.

Happily, the citizens of America are beginning to realize the evils of private corporate monopoly and the impotence of municipal authorities to resent their encroachments on our purses and liberties. But they have yet to learn that private corporate monopolies can only be met by the municipal adoption of private corporate methods, and that in the competition thus established the public power will certainly prevail.

No private gas corporation can possibly exist in Birmingham, not because the citizens sentimentally object to them, for assuredly they have no such prejudice,—indeed, there are hundreds of other private corporations in the city—but because the municipal authorities are able to provide the necessary capital at a lower rate of interest than a private corporation, and can also secure the services of the most accomplished experts and erect the best machinery. Therefore, on these accounts, they are able to supply their customers with better and cheaper gas.

The reform of American city government is not a matter of evolution by the methods now in operation. This evolution is on the way to failure, of which the probable acme is the New York charter. It is only through simple deduction, *a priori* reasoning, and actual experience throughout the world, that the conclusion becomes irresistible that the honest adoption of simple council government, founded on the model of all business corporations, affords the only prospect of successful city government. This system has never once been tried in any city of the United States, where municipal institutions are a conspicuous failure, whilst elsewhere it affords examples of success in every quarter of the globe. The crowning advantage is that it removes from municipal government the curse of personal power and patronage, which is the basis of corruption and the food of political machines.

EVEN ACETYLENE IS VERY INEFFICIENT.

It is not generally known that the theoretical limit of attainable candle-power from acetylene, made from calcium carbide produced in an electric furnace, is somewhat less than that actually obtained from incandescent lamps actuated by the same amount of electrical energy. As a matter of fact, a given quantity of light produced by burning acetylene necessitates today an expenditure of from two to three times as much energy in making the carbide as would be required to generate the same light with incandescent lamps. This difficulty is only apparent, however, because inexpensive water power can be used for making the carbide, which may be transported to any distance. In a sense, calcium carbide represents the stored light-producing ability of the energy used in its manufacture.—*The Engineering Magazine*, Vol. XVI, No. 6, page 1004.

EFFICIENCY OF ILLUMINANTS.

A leading authority gives the following as the energy, expressed in watts, required to produce light equivalent to one candle-power as measured by the English standard candle :

	WATTS.		WATTS
Tallow	124	Cannel gas	48
Wax	94	Incandescent electric	3.5
Spermaceti	86	Nernst lamp	1.5
Mineral oils	80	Incandescent gas	1.2
Vegetable oils	57	Arc lamp	.3
Coal gas	68		

Clark's compound: mineral pitch 13 parts, sand 6 parts, tar 1 part.

Trade Literature.

Catalogues mentioned in this department will be mailed gratuitously on application to the concerns publishing them. When writing, mention THE JOURNAL OF ELECTRICITY. Where addresses are not given, they may be found through reference to the Advertisers' Index on page iii.

"Long Burning Arc Lamps." Bulletin No. 2, illustrating and describing the latest or "P. Q." type of enclosed arc lamp for direct current circuits. *Pacific Arc Lamp Company*, 149-155 Fremont street, San Francisco.

"American and Foreign Patents." A popular discussion upon American and foreign patents, trade marks, interference cases, copyrights, etc., together with costs of service. *J. Richards & Co.*, 22 California street, San Francisco.

"Endoscopic Lights." A 32-page brochure, well illustrated, describing the electrically-lighted instruments and attachments for physicians, surgeons and dentists, as manufactured by the *American Endoscopic Company*, Providence, R. I.

"Otto Gas and Gasoline Engines." Two separate pamphlets on gas and gasoline engines of the famous Otto type and manufacture. Illustrations, descriptions and dimensional data are included. *Henshaw, Bulkley & Co.*, agents, 48 Fremont street, San Francisco.

"Transformer Design and Operation." No. 9064. The second valuable production on the use and abuse of transformers for local distribution, and so important, if not vital, are the suggestions therein given that the book should be digested by all station managers. 38 pages, 8x10½ inches. *General Electric Company.*

"The Stirling Water Tube Boiler." A 24-page pamphlet illustrating the principles of operation and some of the noteworthy installations of the Stirling boiler, and briefly setting forth its advantages. *The Stirling Company*, Pullman Building, Chicago, or the *Pacific Coast Machinery Company*, 12 Fremont street, San Francisco.

"The John M. Klein Electrical Works' General Catalogue No. 20." A 140-page catalogue of electrical supplies of every description, profusely illustrated, and containing many tables and much useful information. Issued by one of the oldest and most reliable houses on the Pacific Coast. *The John M. Klein Electrical Works*, 421-423 Montgomery street, San Francisco.

"Filing Cabinets and Business Furniture." No. 26. Caters to the office needs of business men of every complexion, with an infinite variety of filing cabinets and general mercantile furniture which, once possessed, would be held as indispensable. The "card system," as therein described, has evidently been worked out to perfection. 160 pages, 6x9 inches. *The Globe Company*, Cincinnati.

"Ice-Making and Refrigerating Machinery." About 100 pages, in coat pocket size, of information concerning refrigeration processes. Ice-making plants from a capacity of 150 pounds of ice up to many tons per day, as well as refrigerating machinery for rooms 8 feet square up to great abattoirs and packing houses, are discussed with a degree of satisfaction seldom found in a trade catalogue. *Oakland Iron Works.*

"Windmills, Pumps, and Gas Engines." Catalogue No. 26. 88 pages, freely illustrated, giving descriptive price lists of various types of steel and wooden windmills and pumps, as well as of the Webster gas engine. Though this catalogue is very complete, it seems surprising that it should contain no reference to windmills geared for power purposes other than pumping. The book is invaluable for the farm and country. *Woodin & Little*, 312-314 Market street, San Francisco.

"The Modern Roundhouse Turntable." Showing, in an artistic manner, the high degree of serviceability which the electric motor has attained in the operation of turntables for standard railways. The Westinghouse method of applying electricity to the operation of turntables should be especially interesting to railroad managers, inasmuch as it requires no change in the turntable proper, other than attaching the draw bar lug to the turntable girder. *Westinghouse Electric and Manufacturing Company.*

"Thomson Recording Wattmeters." Ten years ago electrical energy was invariably supplied at a fixed rate per month for each installation without much regard to the amount actually furnished. Today electric stations in this country supply on a meter basis the electricity they manufacture with resultant advantage to the station economy. Some idea of the extent to which the meter business in this country has grown may be gathered from the fact that not less than 200,000 Thomson recording wattmeters alone have been manufactured and sold by the General Electric Company. The business has grown from small beginnings by the persistent missionary work which has been carried on by this company through both agents and literature. The latest addition to the meter literature issued from the General Electric press is "Thomson Recording Wattmeters," a handsomely printed and illustrated brochure in a rich cover, dealing with the different types of these recording energy meters which the General Electric Company manufacture, their uses and their advantages. Each type of motor is clearly described and so illustrated that its construction can readily be understood. Full instructions are given for the care, connection and reading of these meters. The pamphlet should be found in the library of every electric light and power station, and will be sent on application made to the Schenectady office of the *General Electric Company.*

The Southern Electrical Company has just opened a large supply house at the corner of Third and South Main streets, Los Angeles. The company carries everything electrical and has one of the largest and most complete stocks in southern California.

TABLE OF CONTENTS.

Illustrated articles are designated by an asterisk (*); Editorials by a dagger (†); Passing Comment by a double dagger (‡), and Industrial by a section mark (§).

Electro-Therapeutics

The Old and the New in Theory.......... 59

Gas

*Industrial Gas, by Frank H. Bates.......... 53
*The Westinghouse Gas Engine, by Edwin Ruud.......... 62

Illumination

Efficiency of Illuminants.......... 67
Even Acetylene is Very Inefficient.......... 67
†Evolution, Not Revolution, is at Hand.......... 60
†"Fools Rush In Where Angels Fear to Tread.".......... 60
‡Inefficiency of Incandescent Lamps.......... 61
No Standard of Illumination.......... 65
One Candle-power per Watt.......... 59
The Lesson of a Municipal Failure, by J. H. Stallard, M. B., Lon- 65
don, etc.......... 65

Miscellany

Electroplating Prevents Fouling of Hulls.......... 65
‡Mining is Its Element.......... 61

Trade Literature

.... 68

Transportation

‡A General Formula for Train Resistance.......... 61

THE JOURNAL OF ELECTRICITY.

VOLUME VII. SAN FRANCISCO, MAY, 1899. NUMBER 5.

The Kootenay-Rossland Power Transmission.

BY GEO. P. LOW.

PART I.

KOOTENAY district includes that portion of British Columbia lying on the Canadian boundary immediately north of Spokane, Wash. It is an exceedingly rough country. The crest of the Rocky Mountain range forms its eastern boundary and the Selkirk and Purcell ranges, paralleling the Rockies, run through its center and thus separate it into its east and west divisions, each of which has an average width of from sixty to seventy-five miles, by a length of over two hundred miles. The district is very heavily wooded with dense underbrush or of bleak and barren granitic formation, according to altitude or precipitousness, and the wild, rugged grandeur of mountain scenery, which has, above all other features, made the Canadian Pacific Railway world-famed, is mostly located within its confines. Curious indeed too, are the formation of its lakes and water courses. Inland fresh water seas, almost innumerable, and of all shapes and sizes, mark the country on every hand, and the multitude of rivers supplied from them eloquently bespeak permanence for the sources of the mighty Columbia. Water is everywhere, as are also the Indian and frontier names, euphonious or otherwise, such as the town of Illecillewaet, the Spillimacheen River, or Horse Thief Creek. But an idea of the broken and erratic topography of the Kootenay district can not be better conveyed than by reference to the seeming antipathy which the Columbia and Kootenay rivers bear each other in their early courses. The Columbia has its source in Upper Columbia Lake, whose head or southern extremity is about fifteen miles above the Canadian boundary line. Thence the Columbia flows in an almost due northwesterly direction for practically two hundred miles, whence it turns southerly and then westerly, first through the West Kootenay district and then into the United States and on to the Pacific Ocean.

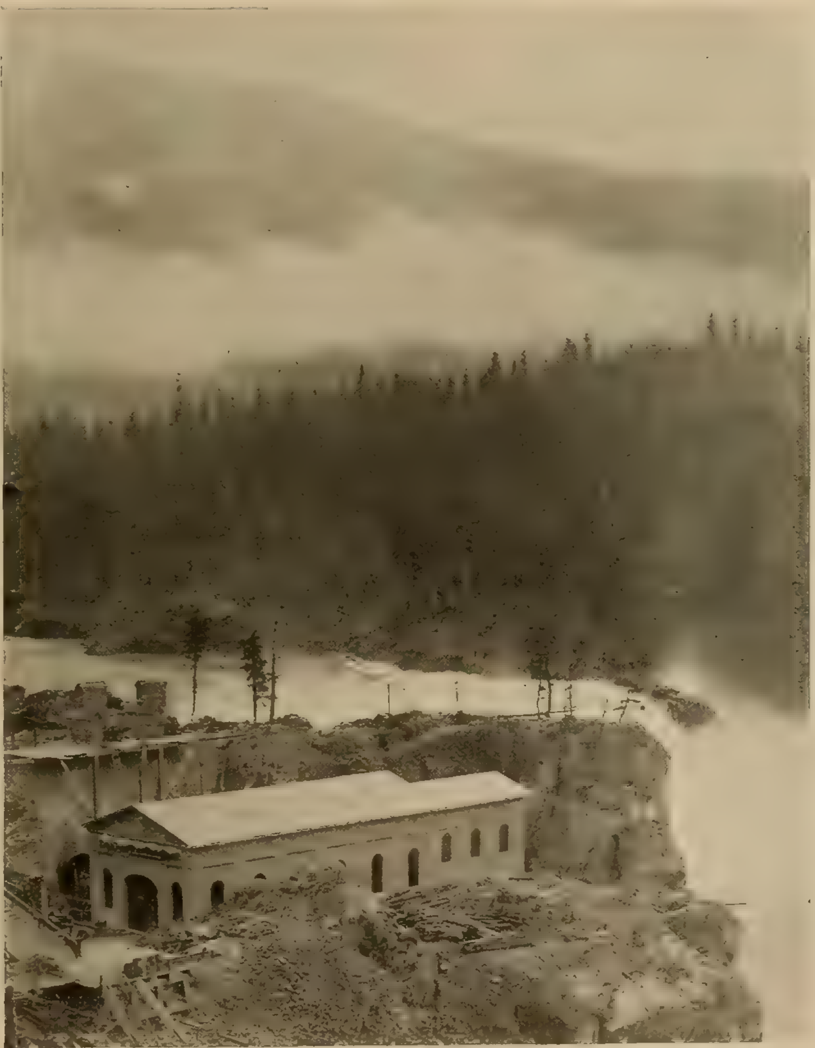


FIGURE 1.—LOWER BONNINGTON FALLS AND POWER HOUSE.

A few miles east of the Columbia, at a point some sixty miles below its source, are two comparatively small lakes a mile or so apart. From the northerly one the Beaver Foot River rises, eventually reaching the Columbia; in the southerly lake the Kootenay River finds its source and continues down in a southeasterly direction, parallel with and at a distance varying from ten to fifteen miles from the Columbia River, though the streams flow in opposite directions for about sixty miles. When the head of the Columbia is reached and further paralleling is impossible, the Kootenay approaches within three miles of its rival river but quickly turns from it, flowing away one hundred and fifty miles further south into Montana, whence it retraces its course into British soil and finally joins the Columbia near Robson, some thirty miles north of the boundary line. Before doing so, however, it forms the Kootenay Lake, which is perhaps sixty miles long and from four to eight miles wide, and from the lake it continues to the Columbia through a broad, resistless water course something less than fifty miles in length. It is near the lower end of this portion of the Kootenay River, which forms the connecting link between Kootenay Lake and the Columbia River, that the Bonnington Falls are located, and at the lower Bonnington Falls is the generating station of the West Kootenay Power and Light Company, Limited. Thirty-two miles distant is Rossland, which is one of the newest and most prosperous and promising gold mining camps in British Columbia, and in which electricity is not only fast superceding all other forms of power in mining work, but is also even put to characters of mining service ordinarily classed as impossible of accomplishment. It has been my fortune to make personal examinations of the principal electric power transmissions of the West, and it is without hesitation that I state that in none of them is the West Kootenay transmission exceeded in points of thoroughness, of engineering design and commercial advantage. While the heroic manner in which it has grappled with every phase of the power problem as applied to mines, and the thoroughness with which it has worked out the complete solutions of these problems, enables it to stand alone as one of the most perfect mining transmissions to be found on the Pacific Coast. After long familiarity with experiences which have been had in California transmissions in attempts, generally futile, to operate mining hoists by induction motors, one is quite unprepared on reaching Rossland, to be informed that for months the War Eagle hoist at that place has been operated by a 300 horse-power induction motor and that the service therefrom has been absolutely perfect, so perfect indeed, that the Le Roi mine is to have its steam hoist displaced by a hoist operated by a 500 horse-power induction motor after the plan of the War Eagle hoist as soon as the Kootenay company has enlarged its plant and can furnish power for its operation. All electrical and mechanical details concerning these and many other features of all-important interest will be given in this article.

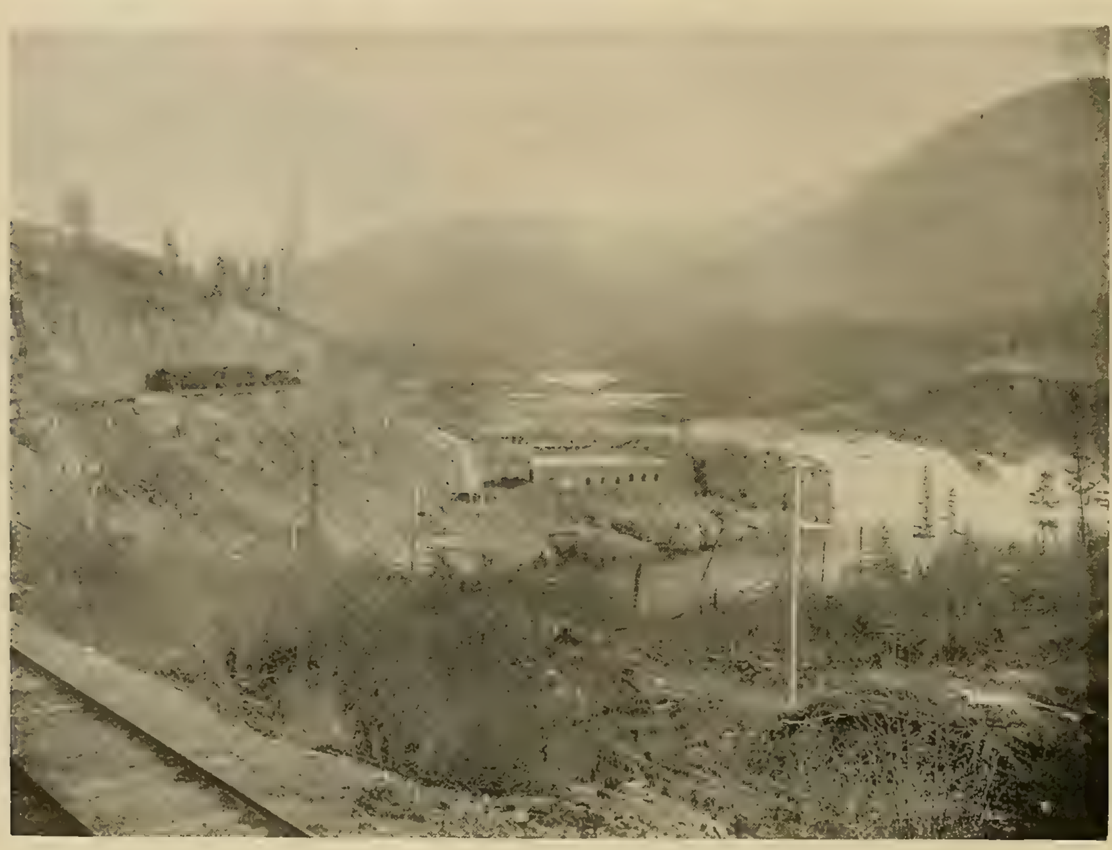


FIGURE 2.—A GENERAL VIEW OF BONNINGTON FALLS AND THE POWER HOUSE.

Among these further features may be briefly enumerated the extraordinary thoroughness and reliability of the water power development, the difficulties which attended the building of the pole line over a rugged route wherein could be found but a few miles of practically level line out of the entire distance, and where, in its length of 32 miles the altitude of the line varies at different points by over 2200 feet. A novelty in the line construction consists in the use of roofed poles and cross-arms, and the Columbia River is crossed with a single span 1500 feet in length without the use of supporting cable. The plant was built essentially for power purposes and of its present load only about twelve per cent. is in lighting, the remainder being in both synchronous and induction motors in mining duty for the operation of compressors, hoists, rock breakers, roasters, bricquetting machines, blowers, machine shops, and other equipments used in and about mining and smelting work.

The general view of the Bonnington Falls, upper and lower, and the country about the power house is given in the accompanying engraving. Here the Selkirk Mountains rise to an elevation of over 1300 feet above the river, or to an elevation of about 3500 feet above the sea level, and the beautifully snow-capped peaks of the rugged range, together with the grandeur of the chain of the falls, forms a charming and picturesque scene. At low water the falls, both upper and lower, are capable of delivering

267,000 horse-power, but the West Kootenay company has thus far attempted to utilize only a portion of the lower falls, which, under the 40 foot head available at extreme low water, are capable of delivering 100,000 horse-power. The river is 400 feet wide at the lower falls and in developing a portion of its water power, the West Kootenay company constructed a canal 650 feet in length and some 26 feet in width, all through the hard country rock. Towards its lower end the canal widens out into a forebay 54 feet in width, the forebay being closed in by a solid concrete dam 32 feet high and 26 feet in width at the bottom, tapering to six feet in width at the top. Between two high bluffs at a point in the head race, 150 feet above the concrete dam, has been constructed a wooden dam sloping at an angle of 42 degrees up stream and having a vertical height of 44 feet. The sills and timbers of this dam are spaced five feet apart, and all timber, including sills, are of 12 × 12 material solidly bolted to the rock, the whole being then planked by a double layer of four-inch planking. In the bottom of this dam are five sluice ways and its object is to break the impact of water flowing into the head race from the canal during high water, or, in general, to insure the control of the water entering the forebay at all times.

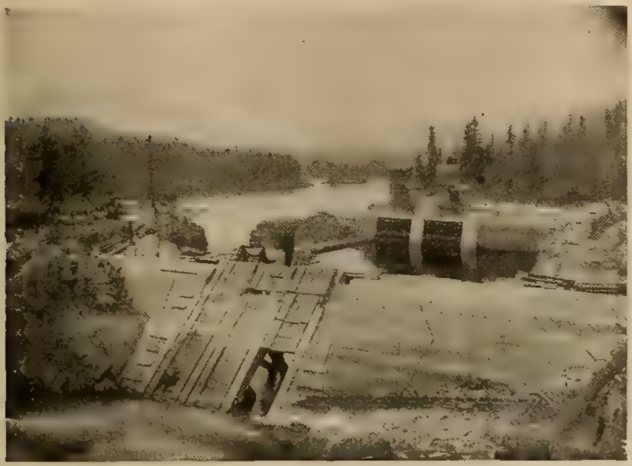


FIGURE 3.—WOODEN AND CONCRETE DAMS AND FOREBAY.

Lower Bonnington Falls have an extreme difference of level of 32 feet, which measures the head of water available at the power house. The main concrete dam is provided with three feeders, two of nine feet each and one of ten feet. The upper ends of the feeders are closed by gates which measure respectively 12 feet by 13, 12 feet by 13, and 13 feet by 14. These gates are of wood, and consist of a framing of 12 × 12 timber to which is solidly bolted eight-inch planking. The two outside frames extend upward of 38 feet and to the walls of each pit are bolted the racks for raising and lowering the gates. The gates are further provided each with a small iron flood-gate, 12 inches by 12 inches in size, and the main gates are raised and lowered by means of headgate irons rigidly bolted to the top of the dam. The winch controlling the headgate irons are operated by one man. These and other features are admirably shown in the drawing on page 73 showing the end elevation of the dam, power house and tail race. The three steel penstocks, each nine feet in diameter by 20 feet in length, run through the concrete dam into the hydraulic section of the power house near the base of the dam, and from each penstock is carried a ten-inch stand pipe, the height of which nearly reaches the top of the dam. The back of the dam practically forms one side of the power house and tail race, the latter extending at right angles to it and consisting of a pit approximately 30 feet in depth by 20 feet in width, extending nearly the length of the power house, which is 66 feet. In the clear water the tail race is flanked by built masonry and concrete retaining walls which vary from four to six feet in thickness and extend upward to approximately the level of the power house floor. The floor plan of the power house shows the arrangement of the turbines and their mode of connection to the generators. Bolted to the lower end of each penstock is a 13-foot casting containing one pair of 39-inch horizontal cylinder gate turbines. To these castings or wheel housings are bolted the draft tubes, which are 22 feet in length and ten feet in diameter at the lower end. The housing is supported on each end by the retaining walls of the tail race and are further carried by I beams. The turbines for driving the exciters are supplied with water taken from the main turbine housings in the manner shown on the ground plan of the power house.

To be more explicit, the three 40-kilowatt, 125-volt multipolar exciters are direct-driven from independent, horizontal, 12-inch registered gate turbines which are contained in the cast iron flumes, the latter in turn supported by transverse beams bolted to the main beams of the large wheels, while bolted to the cast iron flumes are the draft tubes and feeders. The latter are connected to the shaftings of the large wheels from which they derive their water supply. The portion of the power house containing the generators and switchboards together with the transformer house built thereon as an L, is bedded on the solid granite rock, which, after being suitably dressed and surfaced with concrete, gave most perfect foundations for the heavy machinery to be placed therein. A single roof

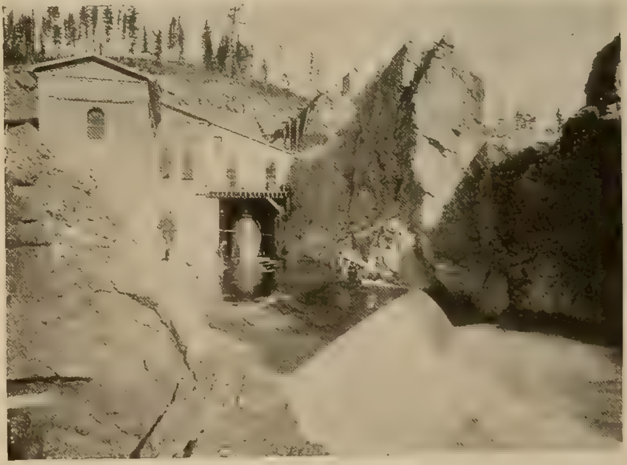


FIGURE 4.—REAR VIEW OF POWER HOUSE SHOWING DRAUGHT-TUBE AND TAIL RACE.

covers the entire structure with the exception of the transformer house which is independently roofed. The building is fireproof, with walls of brick and roof of wood covered with galvanized iron. The inside dimensions of the turbine house are 25 feet by 64 feet; those of the generator room are 31½ feet by 66 feet, while the transformer house measures 17½ feet by 28 feet. A flight of nine stairs takes one from the floor of the generator room to that of the transformer house, the difference in elevation of the two floors furnishing space for the blowers of the air blast transformers and ducts, as will be described hereafter. The height of the building from floor to the ridge of the roof is 40 feet, and ample room is thus provided for substantial framing on which to carry the high tension leads.

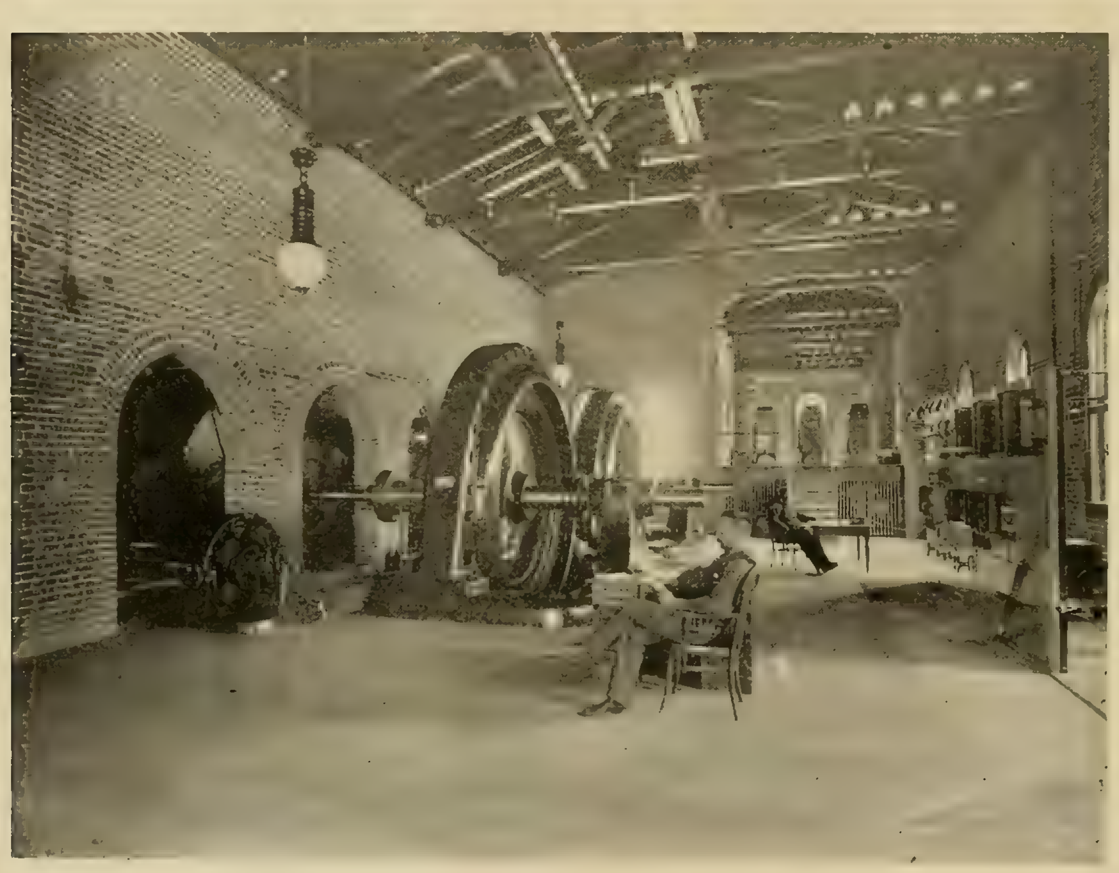


FIGURE 5.—INTERIOR OF THE WEST KOOTENAY POWER HOUSE.

Two 750-kilowatt units have been in operation in this power house since last summer, and the third generator, which is a 1500-kilowatt unit, is at present under erection and will be in operation at the earliest possible moment in order to relieve the overload under which the plant is now laboring, as well as to take care of the increase in business awaiting its installation. Along with this generator, of course, is being erected an equivalent capacity in raising and lowering transformers which explains why these transformers do not appear in the photographs of the plant, although they are shown as erected in the drawings. The comparatively small difference in the relative sizes of 1500 and 750-kilowatt units, even when run under the same speed as is done in the present case, is strikingly shown in the general plan of the power house, from which it is also obvious that two 1500-kilowatt units with accompanying wheels may be substituted for the two 750-kilowatt equipments as installed at any time, if desired, without necessitating changes in the power house.

These generators are of the standard General Electric revolving field type as built by the Canadian General Electric Company, as is also the entire electrical equipment of the whole installation with the exception of the induction motor operating the War Eagle hoist at Rossland, which was built at the Schenectady works of the General Electric Company. The generators run at 180 revolutions per minute, have forty poles, and deliver 60-cycle, three-phase current at 1100 volts delta. Underground waterproof ducts carry the generator leads to the switchboard, which, when completed, will consist of three exciter panels, three generator panels, three transformer panels, and four ine panells. Nothing of novelty is imparted in the switchboard, as all instruments, appliances and methods are of standard General Electric varieties, with the single exception that the generators are thrown into synchronism on the "out" of the synchronizing lamps, whereas it is the usual practice to synchronize with lamps at full candle power. In this connection it is interesting to note that at the outset considerable difficulty was experienced in synchronizing the generators, but the trouble was finally located as being due to the fact that the slip-rings on the revolving fields were out of true one-eighth of an inch. Rotation thus introduced a varying resistance in the contact between the brushes and slip-rings which, though imperceptible in the voltmeter and ammeter readings, made synchronizing an uncertain performance. However doubtful station engineers may be that the trouble experienced was due to the cause ascribed, it is certain that after the slip-rings were turned down no further difficulty was encountered in synchronizing, which is now done with perfect ease under a variation of 200 amperes.

Ducts placed under the floor carry the leads from the transformer panels to the raising transformers. There are twelve of these, each having a capacity of 250 kilowatts and wound for 1100 volts on the primary with either

11,620 volts 20,100 volts on the secondary, according to whether delta or Y. The higher potential of 20,100 volts is delivered to the line.

It is the opinion of the writer that if it had been the general custom to install air-blast transformers in the manner adopted by the West Kootenay Power and Light Company and to have maintained them under the same care and attendance as the Kootenay company is administering to the air-blast transformers in its installation, a greater degree of success would have attended their use than has been the experience of a few of the many transmissions which have adopted them. More detailed reference to this matter will, however, be given in describing the step-down transformer installation at the Rossland sub-station, as the ideas to be conveyed may be then more clearly set forth by reference to the structural drawings presented, and the principles involved apply equally well to the transformer house at the generating station.

In this transformer house three 60-inch Buffalo blowers together with the two horse-power, 110-volt induction motors from which each is driven, are placed under the platform forming the floor of the transformer house, in the space indicated by the slotted grating behind the stairs. These blowers furnish an air blast to the transformers through large ducts or tunnels after the manner and for the purpose to be described later. The high tension circuits are led from the transformer to porcelain insulators placed on framings overhead in the transformer house and generator room whence they are carried to the line out through eight-inch, vitrified, terra cotta piping built in the front wall of the station. Fifteen such pipes exist, thus providing for five three-phase circuits, and the outside orifices of these outlets are roofed.

THE POLE LINE.

The profile of the Kootenay-Rossland transmission astonishes one because of the extreme irregularity of the country it traverses from one end to the other. In fact it resembles the work of the tracing pen on the recording voltmeter chart of a badly regulated incandescent plant, or perhaps even of a railway power service, much more than the profile of a transmission pole line. There is altogether not over a level mile or two in its whole length, and the grades are of all degrees of steepness, reaching the maximum at about 70 per cent. Its length is practically 31 miles, in traversing which its altitude above sea level varies by over 2200 feet.

Aside from the features enumerated, the pole line embodies two characteristics, each of which is, so far as the writer is aware, without precedent in transmission practice. The pole line is double, and on one of these lines both cross-arms are roofed or snow-shedded. The other distinguishing feature consists in the span of 1500 feet that the line wires take in crossing the Columbia River, these wires being unsupported by cable as will be described. Both pole lines are of a very substantial type of construction, being round, specially selected cedar, and varying in length from 30 to 65 feet, according to location. They are set 100 feet apart, or 50 to the mile, with all corners and curves properly guyed. The right of way lies through a heavily wooded country throughout which a 100-foot clearance has been made from each pole line. The first line built was constructed in the ordinary manner; that is, without roofing, but before it was placed in service the wet snow piled up on the cross-arms to a height of nearly two feet in places, which led to the determination to roof in the second line to prevent any trouble that it was be-

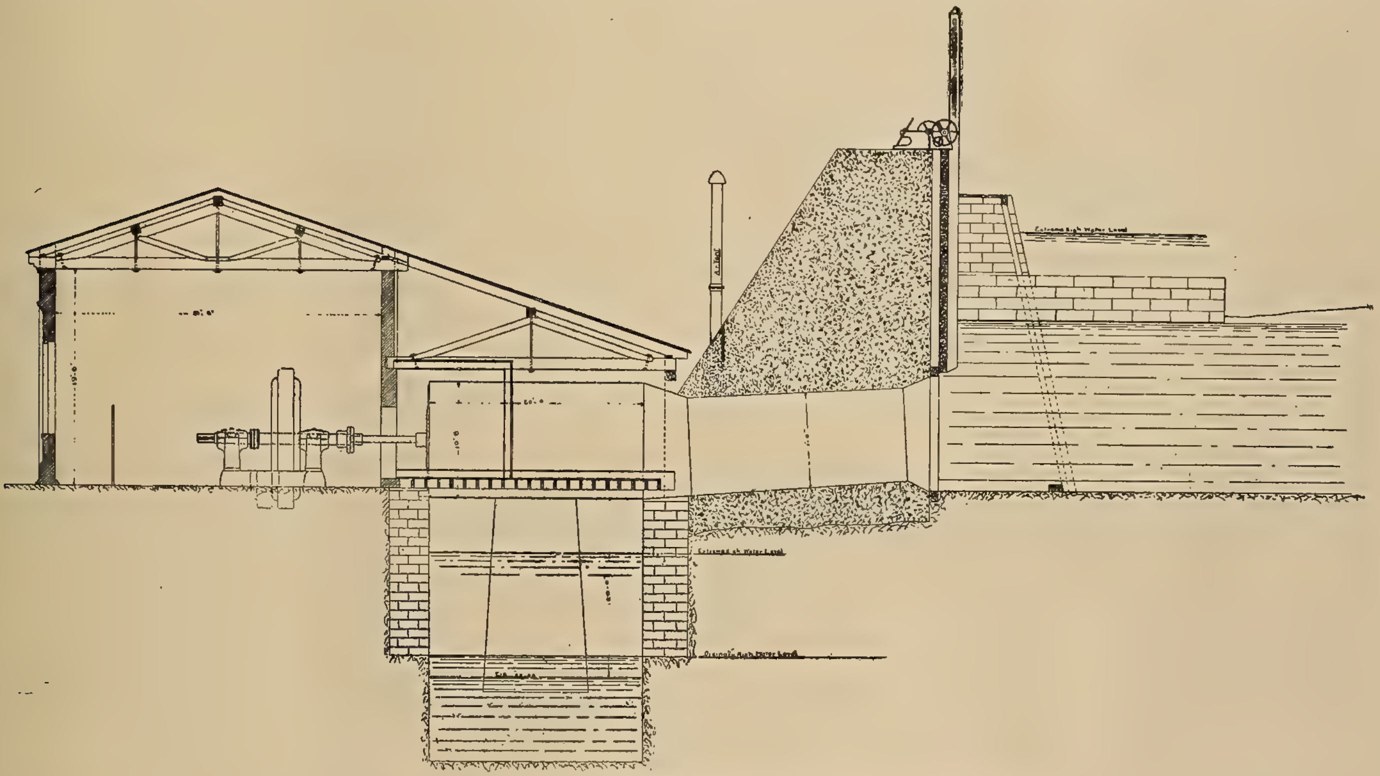


FIGURE 6.—END VIEW OF POWER HOUSE, TAIL RACE AND DAM.

lieved would arise from snow. It should be explained that in the Kootenay country there is no wind whatever during snowstorms and hardly any wind arises at any time during winter. As the snow is of a very wet nature there is nothing to prevent it piling up to the depth named on cross-arms, or its clinging to the transmission lines until the diameter has been increased to four or even six inches, and oftentimes the accumulation will remain until dissipated by the Chinook winds so characteristic of northwestern regions.

The accompanying cuts give the dimensional data of the details and materials used in snow-shedding the second high tension line. As will be seen therefrom both cross-arms are roofed, the upper one, which carries four insulators, being covered with a cedar roofing 24 inches wide, while the width of the roof over the lower arm is but one foot four inches. The details of the construction are, however, given so fully in the drawing on the next page that a description of them would be redundant.

As a matter of engineering information it may be stated that the following comprises the list of materials for each pole:

Two $\frac{3}{4}\times 14$-inch machine bolts with 4-inch threads, galvanized.
Four $\frac{3}{8}\times 5$-inch machine bolts, standard, galvanized.
Two $\frac{5}{8}\times 4$-inch lag screws, standard, galvanized.
Two $\frac{1}{2}\times 7$-inch lag screws, standard, galvanized.
Four $\frac{7}{16}$-inch wrought washers, standard, galvanized.
Two $\frac{9}{16}$-inch wrought washers, standard, galvanized.
Four $\frac{3}{16}$-inch cast washers, standard, galvanized.
Four cross-arm braces, $1\frac{1}{4}\times\frac{1}{4}\times 30$ inches; holes, 28 inches, centers.
Six high potential insulators.
Two double petticoat glass telephone insulators.
Six locust top pins; shank 2 inches, diameter 5 inches long, standard top.
Two oak top pins, $1\frac{1}{2}$-inch, standard.
One fir cross-arm, 4×5 inches $\times 8$ feet, 3 inches.
One fir cross-arm, 4×5 inches $\times 6$ feet, 3 inches.
One fir cross-arm, 3×4 inches $\times 2$ feet, $3\frac{1}{2}$ inches.
Six pieces cedar, 1×8 inches $\times 4$ feet, 6 inches.
Four pieces cedar, 1×8 inches $\times 3$ feet.
Four pieces fir, $1\frac{1}{4}\times 6$ inches $\times 1$ foot, 8 inches.
Four pieces fir, $1\frac{1}{4}\times 3$ inches $\times 1$ foot, 10 inches.
Four pieces fir, $1\frac{1}{4}\times 3$ inches $\times 1$ foot, 4 inches.

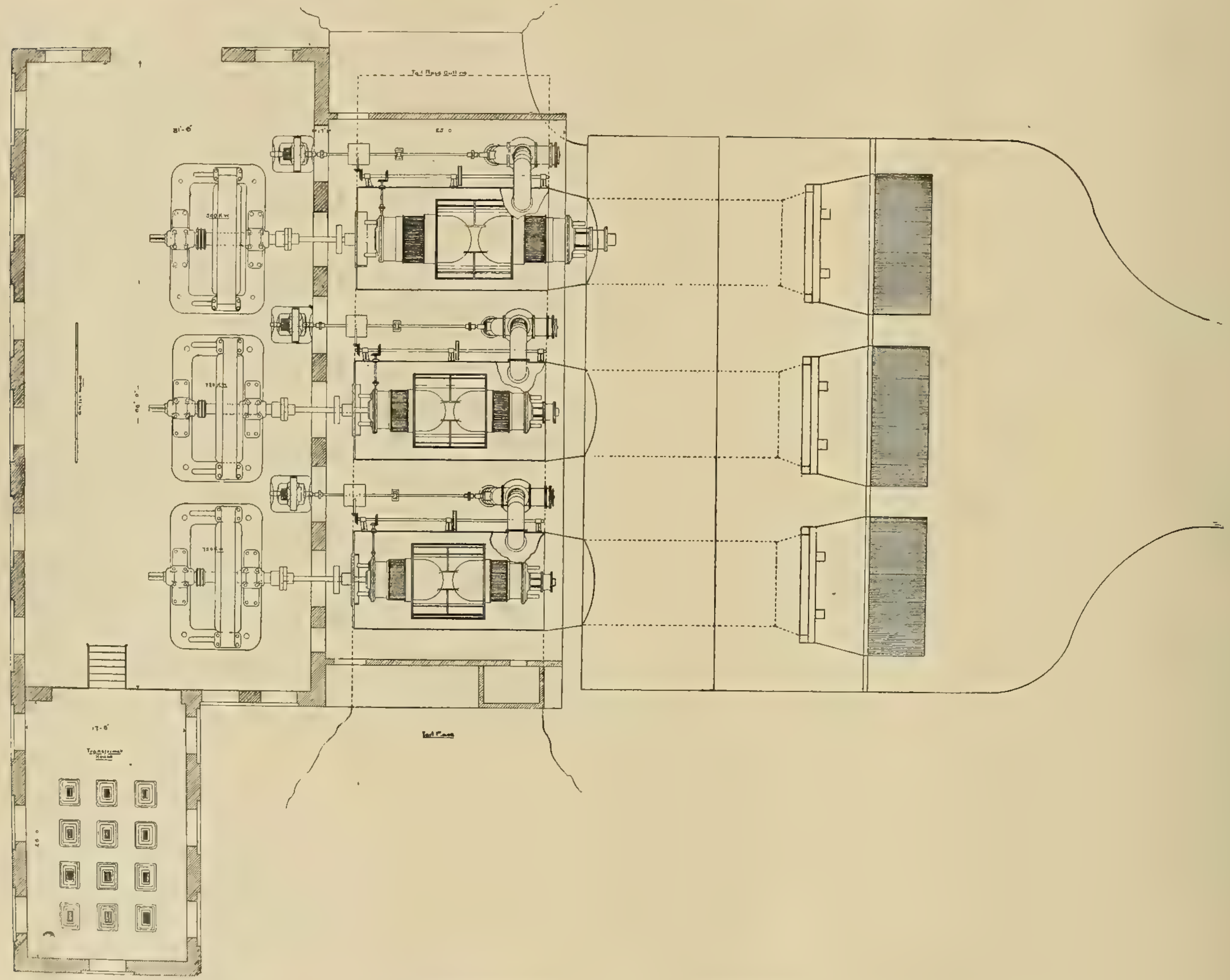


FIGURE 7.—FLOOR PLAN OF POWER HOUSE.

It will be seen by reference to Figure 10, that the pins used are of specially heavy construction, having a shank 2⅞ inches in diameter and 5 inches long from the shoulder. The length of the pin over all is 11½ inches, which gives

6½ inches from the top of the cross-arm to the top of the pin. These pins are of locust and the treatment administered to them consisted in boiling them in paraffine oil, after which they were taken out, and when cooled they were dipped in hot paraffine oil. No further treatment was given. Porcelain insulators of the Redlands type are used throughout, and while the three wires of a circuit in three-phase transmissions are generally placed so as to form an equilateral triangle, the wires of the Kootenay transmission form an inverted isosceles triangle with 20 inches on the base and 22 inches on each of the sides.

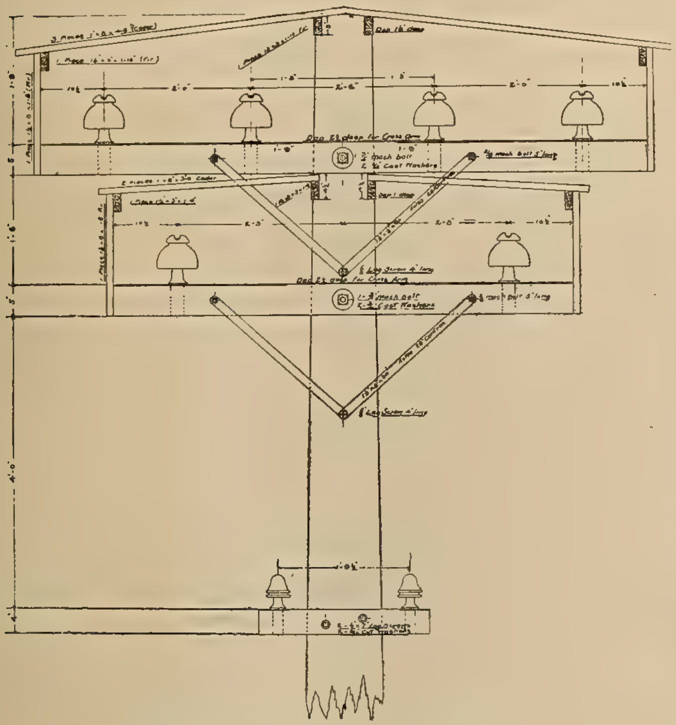


Figure 8.—Detail of Pole and Cross-Arm.

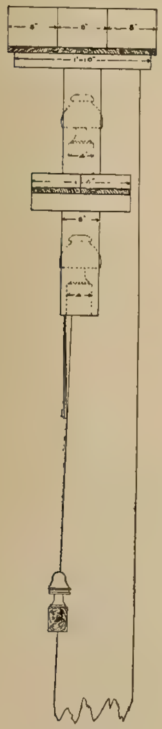


Figure 9.—A Side View of Pole and Cross-Arm.

The illustration on page 77 was taken from the door of the sub-station in Rossland last winter during a period when the snow had accumulated to a depth of from 10 to 12 inches on the cross-arms of both the roofed and unroofed pole lines. It remained in this condition for considerably over a week and service was continued as usual over both pole lines without interruption from snow or any other cause during this period. If any leakage existed between the wires on the unroofed pole line, or to ground, it was impossible to detect it with the appliances at hand and the standard station instruments were in no wise affected by it to any appreciable degree. It is probable therefore, that after the experience of last winter, such other pole lines as the West Kootenay company may erect will not be roofed.

At present two circuits are completed and have been in successful operation for several months, and the third line is now under construction. These lines are of No. 0, B. & S. gauge medium hard drawn copper wire, with the exception of where they cross the Columbia and Kootenay Rivers, where they are changed to No. 000 bimetallic wire, the increase in cross-section being for the purpose of maintaining the conductivity of the bimetallic wire equal to that had in the regular line. The Kootenay River is crossed in a single span of 600 feet, while the span across the Columbia River is 1500 feet in length. These spans are unusual because of their length and the fact that, as previously stated, they are not supported by strain cables. The methods pursued in crossing each river are the same and on page 76 is given a view of the tower and strain frame on the Rossland side of the Columbia River at the crossing. The No. 0 copper lines terminate at the square strain frame shown near the center of the photograph; and at this point also, the bimetallic lines are anchored and carried thence to the 125-foot tower in front, whence begins the span across the river. There is a sag of 52 feet in the total stretch of 1500 feet, and the strain is supported on ordinary porcelain insulators placed close together and mounted on very substantial framings. At times wet snow has adhered to the line wires at these crossings until it has reached a diameter of about four inches, yet trouble has not arisen therefrom nor from swinging crosses at the rivers, as the separation of six feet that has been placed between wires at these points has proven adequate to prevent it. In fact the service has not been interrupted since the starting of the plant, but on two occasions, one line or the other was broken by the falling of trees that were supposed to be beyond reach of the lines. The photograph showing the tower and strain frames at the Columbia crossing was taken during construction, hence the line wires at the crossing are not shown.

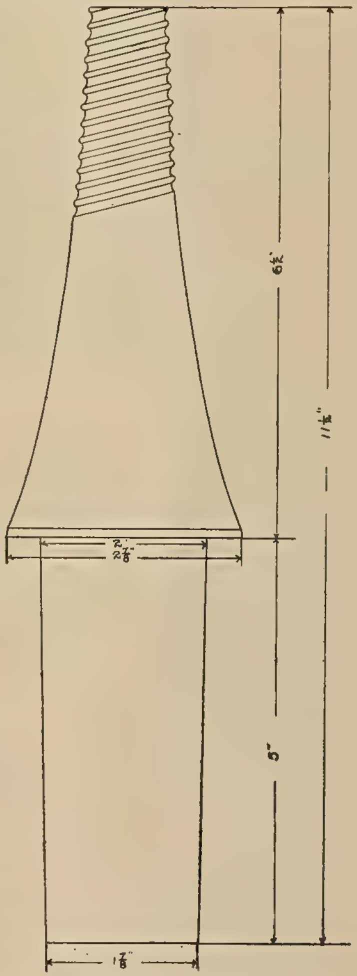


Figure 10.—Details of Pin.

At a point three miles from the sub-station in Rossland branches are taken off at right angles and carried to the town of Trail, B. C., which is four miles by pole line from the main line. At Trail, where is located the great smelter of the Canadian Pacific Railroad, the three-phase

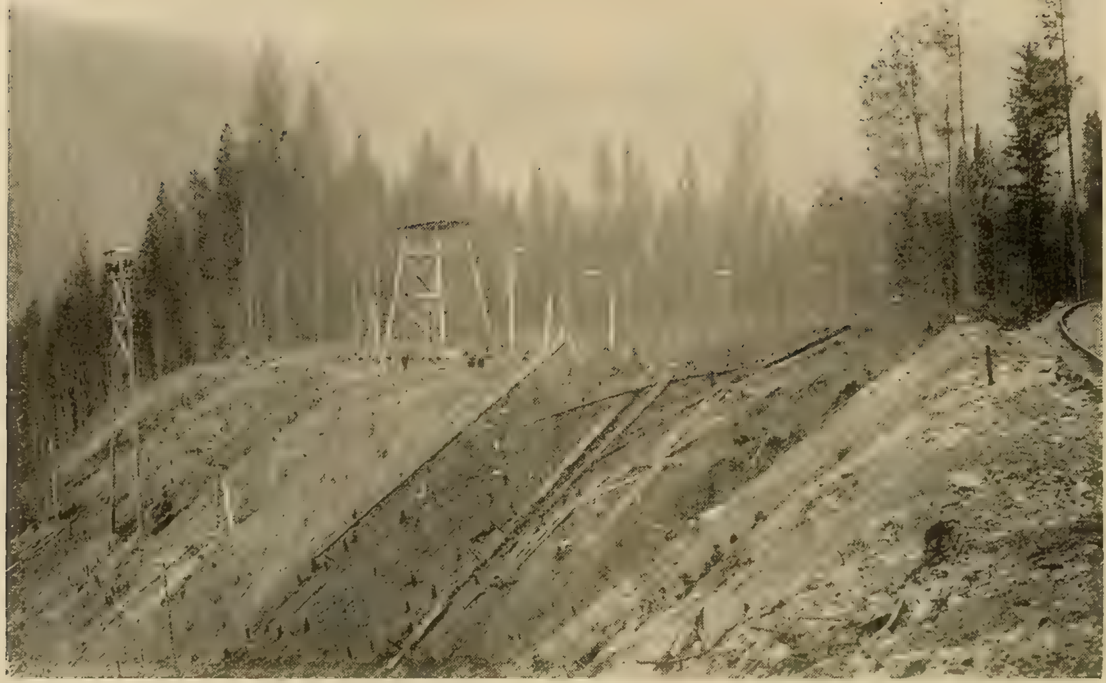


FIGURE 11.—TOWER AND GALLOWS FRAME ON ROSSLAND SIDE OF COLUMBIA RIVER CROSSING.

current is taken into a neat brick sub-station containing the usual equipment of choke coils, lightning arresters, and the high and low tension switchboard panels necessary for the safety and control of the three 135-kilowatt, oil-insulated, air-cooled, static transformers therein. These deliver three-phase current at 550 volts for the operation of various portions of the smelter.

So variegated are the uses to which electric power is put in these premises, and so characteristic is the installation as representing the various kinds of service that may be rendered with the utmost reliability by electric power, that specific reference to the duties performed by some of the motors will be of interest. Two 75-kilowatt synchronous motors, for instance, drive Connorsville blowers for the blast furnace, each motor operating a separate blower, while a third Connorsville blower is driven by a 50 horse-power induction motor. All the remaining motors about the smelter are of the induction type. A 50 horse-power motor drives a rock breaker and another 50 horse-power motor operates the lead mill. The machine shop is driven from a 30 horse-power induction motor; another one drives the O'Heara roasters in the O'Heara building, and a third 30 horse-power motor drives the Bruttner roasters in the Bruttner building. These motors are all of Canadian General Electric manufacture and the only Westinghouse motor about the smelter is a 40 horse-power, type C induction motor which operates a bricquetting machine. The limit of transformer capacity has been reached in the service thus far installed in the Trail smelter, and such eminent satisfaction has resulted from the use of electric power that numerous extensions, among which is to be an electric tramway, are to be installed at once. During the year the Trail line will probably be taken from the main line and carried through to the Rossland sub-station.

(To be concluded in June number.)

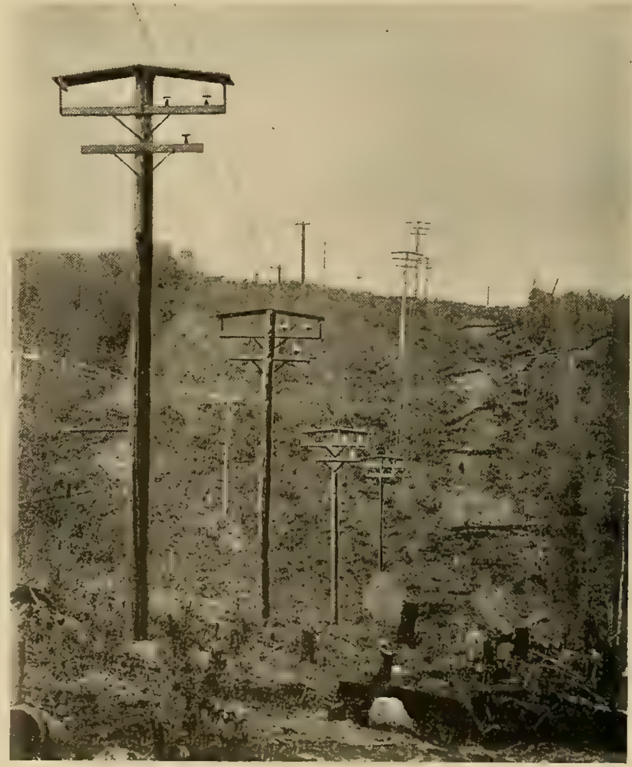


FIGURE 12.—THE METHOD OF TRANSPOSITION.

Transmission

SYNCHRONOUS AND INDUCTION MOTORS.*

BY CHARLES F. SCOTT.

ALTERNATING current polyphase motors are of two types, the synchronous motor and the induction motor. Synchronous motors are similar in general to alternating current generators; there are field magnets which are magnetized by a direct current, and the general construction of the machine is similar to that of the generator. In fact the same machine is often used to perform the double function sometimes of motor and sometimes of generator. The speed of the synchronous motor bears an exactly definite ratio to that of the generator which drives it, independent of the load upon the motor. If the maximum capacity of the motor is exceeded it will stop; it has little torque at low speeds, and is usually started without load, and often a separate motor is used for starting it. Direct current must be provided, usually from a separate machine, for exciting the fields. It is much better adapted for large powers than for small sizes in miscellaneous work.

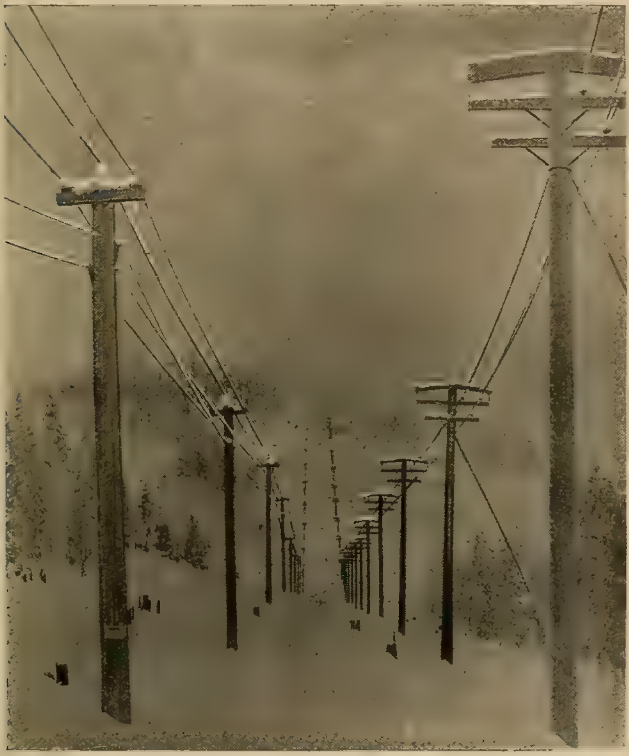


FIGURE 13.—TEN INCHES OF SNOW AND 20,100 VOLTS.

In the induction motor the currents in one element are not obtained from any external source, but are induced or generated wholly within its own winding, very similar to the currents induced in the secondary of a transformer. When this introduced or secondary element rotates, there need be no brushes nor electrical connection with the windings. The wires from the circuit are connected to the wires in the outer or stationary element, so that there need be no open or moving contact of any kind in connection with the motor. This describes the motor in its simplest form. There are modifications sometimes; the primary element revolves and the currents are introduced by brushes resting on rings, and sometimes the revolving element has windings and resistances which are adjustable either by hand or automatically. These modifications sacrifice some of the elements of a simplicity which is of special value in many kinds of work.

The induction motor tends to run at the same speed as a synchronous motor, which has the same number of poles, but there is a slight falling off in speed, or "slip," which increases as the motor is loaded. The speed variation of the induction motor between no load and full load varies with the size and design of the motor, but does not exceed a few per cent.

The synchronous motor receives power from the circuit very much as a shaft receives power through gearing. The speed is absolutely and rigidly fixed by the driving power. On the other hand, the action of the induction motor is like that of a pulley driven by a belt; there is flexibility, slip. A heavy load does not break any gear teeth nor throw the motor out of step; there is simply greater slip and there is nothing to be feared until belt or motor begins to smoke.

The constant speed induction motor above described, has an overload capacity of several times the full load torque. It is started either by connecting it directly to the circuit, which gives a starting torque considerably greater than the full load torque, or it may have a low electromotive force applied for starting with a reduced torque and a reduction in the current required for starting. Ordinarily, the motor is provided with a double-throw switch, which is thrown in one position for starting and in the other position for running.

The induction motor may have a special winding by which either of two numbers of poles may be secured. For example: A 3600-alternation motor may have either four poles, giving a speed of 900 revolutions per minute, or six poles, giving 600 revolutions, or a motor may have either four poles or eight poles, giving 900 or 450 revolutions. This modification adds something to the cost of the motor.

The induction motor is also made for variable speeds. When running without load the motor runs at the same speed that the corresponding constant speed motor would run, but as it is loaded the speed falls rapidly. The motor starts with greater torque than the constant speed motor. It may be provided with a regulator, by which the electromotive force applied can be varied so that over a wide range the motor can deliver any torque at any speed. This motor is used for cranes, hoists, elevators, and similar work where large starting torques, frequent starting, or variable speed is required.

The description of the induction motor from a mechanical point of view is a negative one—it has no commutator, no collecting rings, no brushes; there is nothing to handle but the switch, and it may be at any distance from the motor; nothing to wear but self-oiling bearings; there are no exposed parts, and there is no sparking and no danger from fire. The alternating current, with its profound and intricate theoretical properties, and polyphase currents with their somewhat confusing relations and reactions, have produced a motor of almost ideal simplicity.

Illumination

LUMINOSITY OF A NERNST LAMP IS DECEPTIVE.

A SINGULAR property of the Nernst lamp that is not alluded to in Mr. Swinburne's recently published paper describing it is pointed out by Mr. T. J. Johnston of Schenectady. Mr. Johnston says that its candle-power is, to use his own words, "enough to deceive the very elect. Persons looking at it and at its apparent illuminating power upon the walls of a room, etc., have made the wildest and most extravagant guesses at the photometer reading. I know that," he continues, "although I have had considerable experience with the photometer both in gas and electric lighting work, I guessed 15 candle-power when the Nernst lamp was giving three. I heard one man of more experience than myself guess 32 candle-power when the photometer was reading five. And another thought it was eight candles when the reading was only ¾ of one candle-power. Why this is so, I can not pretend to say."

Chatterton's compound consists of Stockholm tar, 1 part, resin, 1 part, and gutta percha, 3 parts.

---

*Abstract from a paper on "Electricity in Paper Making," read before the American Pulp and Paper Association.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity and Transmission of Power.

Official Organ of the Pacific Coast Electric Transmission Association.

Subscription invariably payable in advance. Terms—Domestic, One Dollar per Year; Foreign, Two Dollars per Year. The trade supplied by the San Francisco News Company. Advertising rates furnished on application.

GEO. P. LOW, : : : Editor and Proprietor

PUBLICATION OFFICE:
320 CALIFORNIA STREET,
ROOM 14.

Address all communications to
Editorial rooms, 427 TENTH AVE.
Telephone, "Steiner 627."

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME VII MAY, 1899 NUMBER 5

EDITORIAL.

THE NEW TRANSMISSIONS OF THE WEST.

Though it has not been the policy of these columns to publish news notes in editorial form, this has been done from time to time when current events of more than usual interest have transpired. The present time, moreover, is one of great activity in electric transmission work and a trip through the power plants of the Pacific Northwest is one of unfailing interest. Several new plants are now under construction, other enterprises are being projected, and transmissions already in operation are delivering service with the utmost degree of reliability and satisfaction.

The consolidation of the transmission plant of the Pioneer Electric Power Company at Ogden and the Big Cottonwood power plant near Salt Lake City, have resulted in the operation of the Pioneer and Big Cottonwood plants as practically a single station, although they are separated fifty miles. No greater difficulty is experienced in paralleling the generators of these two stations than would be met with were they under a common roof. The Pioneer plant in particular is a superb example of transmission work and nowhere in the country is it possible to find a finer power house or one bearing more numerous evidences of perfect design and management. The load carried by these two stations approaches 4000 horse-power.

Montana has several power transmissions, those to Helena and Missoula being the most prominent, while the transmission from the Big Hole River to Butte, a distance of twenty-two miles, will probably be in operation during the coming summer. This transmission is at present in a peculiar predicament, as will be seen.

Among its many features of interest and novelty, Butte City, Montana, may justly lay claim to possessing the shortest distance high potential transmission line in the world; namely, thirty-three inches at 15,000 volts. This anomalous condition was brought about in this way: Some two years ago the Montana Power Company was organized for the purpose of developing the water power of the Big Hole River at a point about two miles from Divide, on the Oregon Short Line, and electrically transmitting the 4000 horse-power there developed to Butte, 22 miles distant. A crib dam was thrown across the river, the power house was erected, the pole line was built, and the turbines were installed, when, on April 17, 1898, during a freshet, the dam proved itself to be weak by dropping back 14 feet down the river. The entire reconstruction of the dam became a necessity, and further thought of securing power from the Montana Power Company within a year had, perforce, to be abandoned. The new dam is now finished and the early completion of the plant is to be expected.

In the meantime, the steam plants of the Butte General Electric Company in Butte, and to which the Montana Power Company was to have delivered its output, became badly overloaded and the execution of some temporary expedient became necessary to tide over the period until power could be received from the Big Hole transmission. Accordingly, a 750-kilowatt generator, with its complete equipment, including switchboards and raising and lowering transformers, was taken from Divide to Butte, where it was installed, the generator being driven by a twin set of tandem compound Corliss engines. The generator delivers three-phase current at 800 volts to the step-up transformers whence it goes to the step-down transformers over the short transmission named at 15,000 volts, and the lowering transformers deliver 2200 volts to the local lighting distribution circuits, as well as to two induction motors, each of which drives a 125-light Brush arc dynamo direct-connected. Though the arrangement is obviously without the efficiency that would otherwise be attained, it must be remembered that it is the result of abnormal conditions; that it is but temporary, and that its installation was the result of a necessity that became imperative.

The famous Edison station at Spokane will be enlarged during the coming summer by the addition of some six thousand horse-power in monocyclic, street railway, and Edison generators. Work on the foundations of the new station, which is to join the old one on its easterly side, is now in progress and new penstocks and headworks for the same are being installed. Probably the most important electric power transmission to be installed thereabouts is the one going into the Buffalo Hump country near Lewiston, Idaho.

That the Kootenay country, which is across the Canadian boundary line immediately north of Spokane, is not backward in the development of electric power transmission work, will be amply proven by reference to the leading article in this number of THE JOURNAL OF ELECTRICITY. Indeed, it may be said without hesitation that at the present moment the plant of the West Kootenay Power and Light Company is more replete with useful and instructive features than any other transmission throughout the entire West, and it is safe to say that the problems so heroically grappled with in the West Kootenay transmission, and the solutions of which have been so ably worked out, will exercise most far reaching influences. It is essentially a power transmission plant, lighting being merely an adjunct, and its most remarkable feature is the operation of the War Eagle hoist from a 300 horse-power induction motor with a primary potential of 2300 volts and with such ease and celerity as to even bid defiance to direct current equipment for the same character of service. Details in extenso of this extraordinary hoist are given in the leading article referred to, and it is probable that before the year closes a similar equipment, only of 500 horse-power capacity, will have been placed in the LeRoi mine at Rossland. An extension of the Kootenay transmission into the boundary country, 40 miles beyond Rossland, is also among the probabilities of the near future.

Returning again to the state of Washington, one finds in the Snoqualmie transmission to the cities of Seattle and Tacoma, a plant that excites wonderment because of the extraordinary boldness of some of its engineering features. This plant, together with others herein referred to, will be fully described in these columns in due season, but a suggestion of the magnitude of the work undertaken in the Snoqualmie transmission may now be pertinent. Snoqualmie Falls have a sheer drop of 268 feet, or, to convey a comparison, imagine a stream of water as wide as the Claus Spreckels Building, San Francisco, falling from a height equivalent to the base of its dome and varying in thickness from seven to twenty feet at its crest, and some idea will be conveyed of the grandeur of Snoqualmie Falls. The power house has been cut out of the solid basalt over which the falls leap. A shaft ten feet in width by twenty-five feet in length, and approximately 260 feet in depth has been sunk on the river bank a short distance above the falls. At the bottom of this shaft a cavern 35 feet in height, by 40 feet in width, by 200 feet in length, has been cut out of the solid rock, and from the lower end of this a tunnel or tail race ten feet wide, by 20 feet high, by 500 feet in length, has been cut to an outlet below the falls. In this cavern all water wheels and generating equipment, consisting of six 1500-kilowatt, 1000-volt revolving armature three-phasers are being installed, the raising transformers being located in a transformer house at the mouth of the shaft. The transmission line as heretofore described in these columns is of aluminum supported on Locke glass insulators, and here it may be stated that in the opinion of the writer, who has been on the ground and has made a personal examination of the transmission, no evidence of either scaling or pitting or other disintegration or impairment of any kind could be found in the aluminum wires on the Snoqualmie line. Emphasis is placed on this point because of reports that have been persistently circulated anent aluminum in this interesting line. It is probable that the plant will be in operation in July.

As a result of the completion of the Snoqualmie line, it is probable that a very interesting fight will be waged for the control of the lighting and power business of the two chief cities of the Sound. The various railway systems of Seattle have progressed with a consolidation so far as it is possible to go until the city shall have granted a new blanket franchise. This secured, some of the electric lighting companies will probably enter the combination, in which event, all railway and lighting service will be rendered from a single plant, but whether this plant shall be a steam station or the proposed transmission from Cedar River remains to be seen. The Cedar River transmission impresses the visitor to Seattle as being beset with many difficulties in the way of its early accomplishment, and in any event it is probable that before it can be put into operation the consolidation referred to will have been effected creating a demand for a union power station which will be met by the erection of a steam plant on the water front. With coal $1.25 per ton, steam should produce electric power as cheaply if not cheaper than a long transmission that is expensive to install and heavily bonded. The Seattle Gas and Electric Company will, in all probability, hold aloof from a combination, and it gives evidence of preparing to hold its own through the installation of producer gas generators and gas engines, driving electric generators. The Snoqualmie plant will therefore be the third and last party to the triangular fight, and although the business is at present practically entirely in the hands of its opponents, it is probable that in the long run it will make a more than favorable showing, mainly because of the fact that its plant was built by private parties on a spot cash basis, while the bonded indebtedness of its competitors more than quadruples its cost. To the onlooker it appears that finesse and broadly capable business management are all that are necessary to bring the Snoqualmie transmission to satisfactory commercial attainment.

AN INEXCUSABLE FAILURE.

Rumors are persistent through Rocky Mountain regions that the operators of the Golden Gate Mill at Mercur, Utah, have become dissatisfied with the use of electric power therein, and have given orders for the installation of a steam plant with which to entirely displace the use of electric power. Time has not permitted the confirmation of these reports by correspondence, and, in fact, the sources from which the information has been received are such as to make it appear that further confirmation is unnecessary, hence the belief is held that the rumors given are true.

However reluctant a journal may be to publish statements reflecting against the industry it represents, it is, nevertheless, its duty to its colleagues and to itself to hide no evidence which, in its absence, would conceal a fact that might have material bearing in solving the problems of power transmissions. The Golden Gate Mill was operated from the generating station at Provo Canyon, Utah, whence power was transmitted at an initial potential of 40,000 volts to Mercur as well as to the mines of the Tintic district. The Provo-Mercur transmission has been fully described in these columns heretofore,* and is also extensively referred to in Mr. Chas. F. Scott's article on High Potential Power Transmission.† It has long held the distinction of being the highest potential power transmission in commercial operation, though its voltage is nearly equaled by that of the Southern California Power Company, which has now been in operation at 33,000 volts for several months.

---

*Journal of Electricity, Vol. V, No. 6, page 169, June, 1898.

†*Ibid.*, Vol. VI, No. 6, December, 1898.

It is especially unfortunate that the operators of the Golden Gate Mill found it necessary to take steps anticipating the abandonment of electric power for several reasons, first among which is the fact that the installation has been widely advertised as approaching the acme of perfection in the operation of mills of this character from extremely high potential circuits. Secondly, and which is to be deplored the more, because the proposed abandonment of electric power, though in no wise chargeable to any dissatisfaction whatever in the operation or efficiency of motors, transformers, or other similar appliances, is due to the flimsy construction of the pole line, the rendering of reliable service over which has been proven to be impossible. As reported in Mr. Scott's paper, as well as in THE JOURNAL OF ELECTRICITY article which preceded it, no trouble has arisen from the use of the line potential of 40,000 volts, and therefore, neither the pins nor insulators have proven defective, but the reports received have been unanimous on the point that the unreliability of the Provo-Mercur transmission has been due solely to the use of light poles, and, in brief, to a generally cheap pole line construction over a mountainous country, where, especially considering the climatic and atmospheric exposures to the line and the necessity for delivering continuous service, the pole line should have been of the most substantial and stable construction possible. It is stated that during the past winter the interruptions to the electric power service in the Golden Gate Mill have numbered as high as fourteen per month, all due to the cause stated.

It is to be added that the failure of electric power service in Mercur is obviously due to other than electrical causes. It must clearly be classed as a preventible failure, in no wise chargeable to its electrical equipment in any portion, nor to the use of 40,000 volts even in an extremely mountainous country at a high altitude, but instead, let the blame rest where it belongs: to short-sightedness in the building of an unworthy pole line.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

A "JOKER" IN WELSBACH LIGHTING.

The daily press of San Francisco has, of late, contained much concerning the relative merits of the gases produced by two rival gas companies, and the contest between them wages with fast embittering strife. The situation is not without moment to the gas world, and being such, it is interesting to offer comment on a point brought out in the following press clipping:

> The San Francisco Gas and Electric Company yesterday invited the Mayor and members of the Board of Supervisors to witness a test at 116 Stockton street of the relative values of their illuminant and that manufactured by the Equitable Gas Company. President Ackerman and Dr. Chisholm of the Equitable company were also guests of the old company. There was a lengthy argument between Dr. Chisholm and President Crockett, in which the former protested that the apparatus to be used would not give a fair test to two gases so thoroughly different. After much wrangling there was an exhibition of what the old company could do with both gases when they were subjected to its apparatus. Then, in reply to a challenge by the Equitable's president, there was an adjournment to his offices, where the dollar gas was tested with a much different result than that secured in the laboratory of the old company. At the laboratory the dollar gas was but a dim representative of what an illuminant should be, but in its own home its brilliancy could not be questioned. A comparative test with the production of the old company drawn directly from the regular pipes gave to the dollar gas practically an equality as regards the amount required to fill a Welsbach burner.

The contention of the San Francisco company is that the Equitable gas, which is made by the Hall process, has but about half the heat units possessed by the carburetted water gas of the former company. This statement is contested by Dr. Chisholm, executive officer of the Equitable company, who claims that the calorific power of the Hall gas practically equals that of the old company.

Without passing upon this question in any manner at present, let it be assumed that the claim advanced by the San Francisco company is correct, and that, therefore, the Hall gas contains, say, 350 British thermal units, and the San Francisco gas contains 700 British thermal units. The former gas is of 11 candle-power, while the latter is of 22 candle-power. Query: What are the relative values of the two gases for (1) open jet lighting, (2) heating, (3) power, and (4) incandescent gas or Welsbach lighting, it being further assumed that equal volumes of gas at equal pressure are consumed in each case.

The first three questions are quickly decided, for it is obvious that in each case the value of the Hall gas (under the assumptions stated) would be but one-half that of the San Francisco gas; that is, burned in an open jet, but one half the light; in a gas stove, but one-half the heat; and in a gas engine, but one-half the power, would result from the use of the Hall gas as would be available from the carburetted water gas of the older company—*if the assumption holds true*. These facts are by far too evident to require proofs.

As to the Welsbach, one of the ablest authorities on gas engineering has stated to the effect that a given quantity of 350-heat unit gas, if applied to a Welsbach mantle through an argand burner, will heat the mantle to as high a degree of incandescence as will be done by an equal quantity of 700-heat unit gas applied to the mantle through a bunsen burner. The authority referred to is none other than Prof. Vivian B. Lewes, chemist of the Royal Naval College, Greenwich, England, and his exact words on the subject are as follows:*

> The combustion of water gas only develops half the thermal value that is to be obtained from an equal volume of coal gas, and many theorists imagine from this that its power of developing light from a mantle would be less in the same ratio. This, however, is an error, as the gas, being non-luminous, is burned in a burner of the argand type without previous admixture with air, giving a very intense combustion on the surface of the mantle, where the gas and air meet, and thus developing a higher illumi-

---

*From "Water Gas: Its Past, Present and Future," by Prof. Vivian B. Lewes, *Gas World*, London, Vol. XXVIII, No. 721, page 750, 1898.

nating value than could be got from the coal gas in an atmospheric burner.

The water gas referred to in the paragraph quoted is "straight," or uncarburetted water gas, which is the virtual equivalent of the Hall gas in heat units; "coal gas" is the equivalent of carburetted water gas, such as is furnished by the San Francisco company, and an "atmospheric burner" is a bunsen burner. In other words, and under the assumptions made, the bunsen burner as applied to Welsbach lighting, has but half the efficiency of the argand; and, on the other hand, it appears that the high candle-power gas, *i. e.*, the 700-heat unit gas, cannot be applied to a mantle through an argand, probably because of its hydrocarbons. Being inherently different, they must be applied differently, and the relative values of the two gases for Welsbach lighting, under the assumptions made, appear, therefore, to be about equal.

But arbitrary assumption and incontrovertible evidence concerning consumption and calorific values of gases, are by no means equally stable foundations upon which to build a superstructure of conclusions; hence the foregoing is speculative, rather than conclusive. Of the latter, more anon.

Physics

MEASUREMENT OF LOW TEMPERATURES.*

BY WALTER H. DICKERSON, M. E.

THERE are three methods of measuring the low temperatures of liquid air, namely: the hydrogen thermometer, the thermo-pile or thermo-electric couple, and the platinum thermometer. The correct reading of these thermometers all depend on the assumption that the laws which govern their actions at ordinary temperatures, hold good at these extremely low temperatures; consequently, the temperature determinations based on these assumptions can only be taken as approximately correct.

In using the hydrogen thermometer to measure temperature as low as that of liquid air, it is open to the criticism that such temperatures approach the critical point of hydrogen, and this introduces a great chance of error.

In using the thermo-pile or thermo-electric couple, it is calibrated at ordinary temperatures, and a calibration curve plotted. Assuming that the curve conforms to the same laws throughout a wide range of temperature, the curve is exterpolated to cover low temperature readings. The instrument readings are taken at the low temperature and plotted back upon the exterpolated portion of the curve and the temperature then determined.

The platinum thermometer is probably the most reliable of the three, and has been used by most of the European investigators in the greater part of their researches in low temperatures. It consists of simply a fine pure platinum wire, sometimes bare, and sometimes sealed in a small glass bulb, and intended to be placed in the liquid, the temperature of which is to be measured. In using it, its resistance-temperature curve is plotted, a given resistance corresponding to a definite temperature. The resistance-temperature curve of pure platinum, for ordinary and high temperatures, is very nearly a straight line, and produced, passes through the origin of co-ordinates, a portion corresponding to zero resistance and zero temperatures. The resistance of the thermometer being determined, it is plotted on the curve and the temperature deduced. The temperatures thus deduced, depending as they do on an assumption, are always expressed as platinum-Centigrade, or platinum-Fahrenheit, degrees.—*Stevens' Indicator*.

THE FERRARIS-ARNÓ PHASE TRANSFORMER.

ONE of the novelties of the exhibit of Messrs. Ganz at the recent Turin International Exhibition, was a distributing system on the Ferraris-Arnó system, which is described in *The Electrician* of February 3d. This method was suggested by Prof. Ferraris a few months before his death, and it has been successfully worked out by his distinguished assistant, Prof. Arnó.

Suppose an alternating current motor has four coils, *A*, *A′*, *B*, *B′*, set at right angles and connected as shown in Figure 1. If two alternating currents differing 90 degrees in phase are sent through them as shown in the diagram, a rotary field will be produced, and if the armature is given a definite polarity, it will rotate at the same speed as the field. Now if the circuit *B B′* be opened, the motor will work as a single-phase synchronous motor, and it will at the same time generate an electromotive force at the terminals of the circuit *B B′*, differing 90 degrees in phase from the primary current in *A A′*. Once started, therefore, the motor acts as a transformer, the electromotive force in the secondary *B B′* depending on the number of turns in the coils.

With the aid of a stationary transformer connected across the primary as shown in Figure 2, the electromotive force induced in the circuit *B B′* may be made two-phase, although the current in the primary is only single-phase. It is also possible to have three wires in the secondary circuit, making a two-phase three-wire distribution, by following the connections given in Figure 3. This latter method of connection is used especially for starting motors, with the aid of a third wire from one of the transformers. Messrs. Ganz had nine motors in various parts of the exhibition, started on this principle.

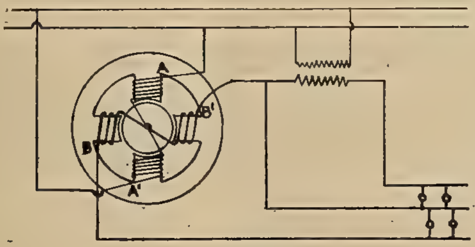


FIGURE 1.

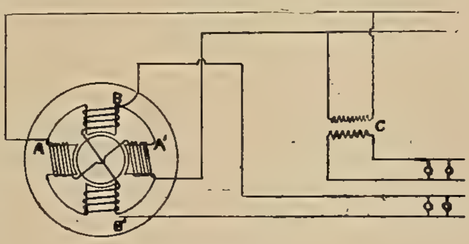


FIGURE 2.

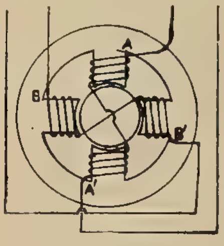


FIGURE 3.

Gas

GAS ENGINES IN ENGLISH ELECTRICAL STATIONS.

GAS engines for operating electric lighting plants are in more common use in Great Britain than in this country, and it is interesting to note the results of inquiries sent by Oliver F. Allen to 35 such plants. Of the 24 replies which he received, the writers of 15 are entirely satisfied and have had no trouble; four have had some trouble with igniters; one has had trouble in starting with a cold cylinder; one engine requires too much attention; one is not able to give information on account of the plant not having been put in operation; one is doubtful, and one is condemnatory. Seventeen of the engines reported are from 30 to 125 horsepower in size, and the owners of the larger engines particularly, express much satisfaction from their use. The gas consumption reported varies from 13.6 to 30 cubic feet per brake horse-power on the basis of 650 heat unit gas. Various makers communicated with guaranteed consumption ranging from 15 to 20 brake horse-power.

INDUSTRIAL GAS.—II.

BY FRANK H. BATES.

THE ELLIOTT APPARATUS. By means of the apparatus already described, it was only possible to analyze a mixture of gases containing carbon dioxide, ethylene (illuminants), oxygen, and carbon monoxide. When it is desirable to ascertain the composition of a mixture containing hydrogen or methane as found in producer gas, illuminating gas, etc., recourse must be had to apparatus which affords a means of burning these gases with oxygen, a measurement of the products of combustion, together with the contraction, enabling one to compute the volumes burned. With Dr. Elliott's apparatus such a determination may be made very rapidly, although at the expense of great accuracy. Owing to the explosion, over water, of the residual gas (the portion remaining after the absorbable constituents are removed), the error of results may be as great as two per cent., although the total error may generally be kept within one per cent., which will meet the requirements of technical work. In iron and steel works, metallurgical establishments, for glass-ovens, and regenerative furnaces using producer gas, and for the analysis of chimney or flue gases, the "Elliott" makes possible sufficiently rapid work to enable the operator to keep in constant touch with the various changes taking place.

The principal innovation with this apparatus lies in the treatment of the gases by permitting the reagents to spread and run down the sides of a long tube containing the gas mixture, bringing the absorbent in intimate contact with loss of but little time.

Description. It consists of an absorption tube A (Figure 4), measuring burette B, and explosion burette C, all graduated to 100 cubic centimeters, although of but one-half the indicated capacity. The two burettes, B and C, are divisioned in tenths of cubic centimeters. The bulbs, at the junction of the tubes A and B with the capillary tubing, serve to render the apparatus more compact by lessening the height, and, in the case of the absorption tube A, provides a means of spreading the liquid reagents used. At the lower end of the absorption tube A is inserted, by means of a cork C', an arm of capillary tubing, which communicates by the three-way stop-cock D' with the level-bottle M, through the arm E' and rubber tubing fastened thereon, and affords an exit for the discharge of reagents by way of the arm V. Above the horizontal capillary on the tube A is a stop-cock B' communicating with the open end A', ground tapering to receive the funnel F' by which the reagents are introduced. The horizontal capillary just below is cut off square at the ends I' and J' to permit of a piece of glass capillary tubing G, being inserted to form a close joint with a short piece of rubber tubing H holding it in place. A similar arrangement is provided for the ends K' and L', thus connecting the three tubes. The lower ends of the measuring and explosion burettes are drawn out to receive rubber tubing with which to connect with the level-bottles N and P. It is advisable to fasten the rubber tubing on the projecting ends by wire ligatures, necessitating the use of three level-bottles, which is preferable, in the writer's opinion, to loose connections and frequent interchange, as is the case when but two are used, as supplied by the makers.

Near the lower end of the explosion burette, below the rubber stopper R' of the water-jacket W, projects an arm of capillary tubing U' with a stop-cock T', through which to introduce the air and oxygen (or hydrogen) used in the combustion of the residual gas. Above the rubber stopper Q of the water-jacket, are fused two platinum wires P' for an ignition spark. The water-jacket W serves to prevent undue heating of the burette during combustion, saving time which would otherwise be required for its cooling. As directed in connection with the Orsat, when the measuring burette is subject to changes of temperature during an analysis, it should also be water-jacketed. The explosion burette is made of heavy glass and there is consequently but little liability to fracture with the exercise of proper care during the explosion.

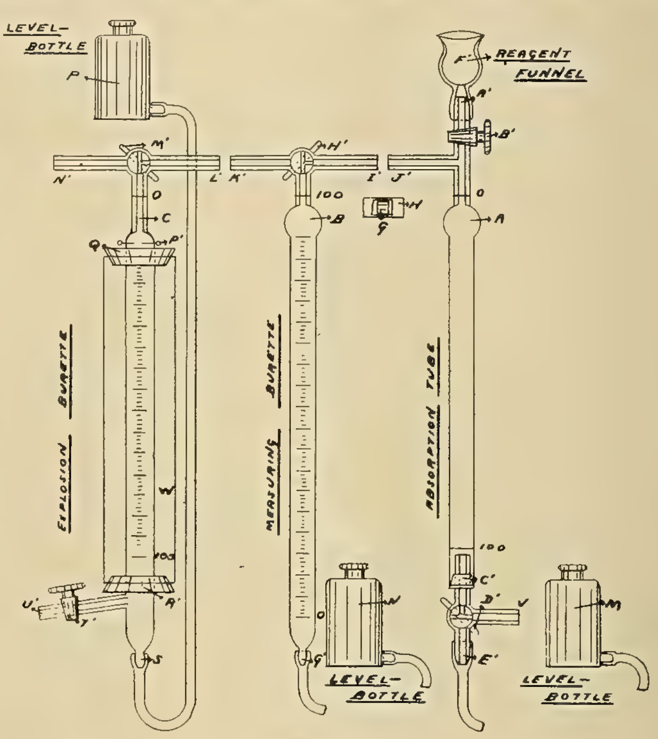


FIGURE 4.

Operation. Before commencing an analysis, about two liters (approximately two quarts) of water should be saturated with the gas under examination, to prevent, as far as possible, the washing out of the soluble constituents of the gas mixture, previous to their absorption by the reagents. With this apparatus the gas is successively treated with the absorbents, as was done with the improvised tubes shown in Figure 1*, differing in this respect from the Orsat. The absorptions are made in the absorption tube A (Figure 4), and the subsequent measurements in the burette B. In preparing for the analysis the level-bottles M, N and P are nearly filled with the saturated water, the connections on the horizontal capillary tubing between the ends J' and I', K' and L' being made, stop-cocks D′, H′ and M′ are opened to give a passage between the level-bottle M and absorption tube, and both through the horizontal capillary and into the measuring and explosion burettes. A rubber tube should be fastened on the end V of the projecting arm from the stop-cock D′, to carry off the waste liquids to the drain.

---

*See THE JOURNAL OF ELECTRICITY, April number.

Open stop-cock B′ and raise all three level-bottles, filling the entire apparatus with water, thereby expelling all air. Close three-way cock M′ so that the run is just closed to the capillary, bringing the outlet up, the reverse of the former position. (In speaking of three-way stop-cocks the long or through passage will be termed the "run," and the branch at right angles to this the "outlet.") Close stop-cock H′ so that the run and outlet are closed to the capillary and measuring burette respectively, with the outlet down. Close stop-cock B′, taking care that the water overflows at the end A′. Open stop-cock T′ on the explosion burette to allow the air, caught in the capillary portion, to escape; close when water overflows at the end U′. We are now ready to admit the gas sample.

Connection is made at end A′ of the absorption tube with the gas source. The level-bottle M is lowered and stop-cock B′ opened to admit a little more than 100 cubic centimeters of gas. (The actual amount admitted will be a little more than 50 cubic centimeters, inasmuch as all three tubes are graduated to read double the capacity to avoid computation in deriving the percentages.) With stop-cock B′ closed, open stop-cock H′ bringing the outlet up to the main capillary, and the run up and down (the position shown in Figure 4), when connection will be made between the absorption tube and measuring burette. Raise level-bottle M and lower level-bottle N, causing the gas to pass into the burette. Now raise the level-bottle N to a height that will bring the level of the water therein to the zero or lowest graduation on the scale of the burette B. Retain in this position, and after waiting one minute for the walls of the burette to drain, lower level-bottle M a little, causing the water in the burette B to rise to the zero mark; then close stop-cock H′ with the outlet up, when the burette will contain exactly 100 cubic centimeters of gas under atmospheric pressure. The error due to the capillary tubing between the 100 cubic centimeter mark and the stop-cock H′ is of no consequence, since the tubing in this half-sized apparatus is but one millimeter internal diameter, requiring 127.3 millimeters (5 inches) of length to give one-tenth of one cubic centimeter. It might be remarked here that any error consequent upon the retention of air in the capillary tubing, will be slight, but may be readily estimated by measuring the length of the air bubble. The gas remaining in the capillary and absorption tube may now be expelled by raising level-bottle M, opening stop-cocks H′ and M′, to make connections with exit N′ (having the outlets of the three-way cocks up) and stop-cock B′, closing all three, on the overflow of water, to their former positions. Transfer the 100 cubic centimeters of gas by raising the level-bottle N, lowering the level-bottle M, and opening stop-cock H′, so that it communicates with the absorption tube. Have the water rise in the measuring burette until it reaches the absorption tube end of the horizontal capillary, thus causing all the gas to pass over, when stop-cock H′ is to be closed, with outlet up. Place the funnel F′ on the end A′, noticing whether there is any air in the vertical capillary; if so, it can be dislodged by inserting a copper wire, with a little water in the funnel. We are now ready to treat the gas with the reagents.

Determination of Carbon Dioxide. The first determination is, as in former instances, that of the carbon dioxide. The reagent, potassium hydroxide, is poured into the funnel F′, filling the latter about two-thirds full, before opening the stop-cock B′ just enough to allow of the reagent spreading evenly around the bulbed portion of the absorption tube A, and running slowly down the sides. Never allow the reagent in the funnel to quite reach the top of the vertical tube, lest air be admitted. Sufficient of the potassium hydroxide should be added to suit the requirements of the gas under examination, a very little sufficing as a rule. On the admission of the proper amount, close stop-cock B′ and transfer the gas to the measuring burette by opening stop-cock H′ and raising and lowering level-bottles M and N respectively, closing stop-cock H′ as soon as the water from the absorption tube reaches the vertical capillary of the measuring burette. Wait one minute before making the measurement, for the walls of the burette to drain; then, with the level of the water in the measuring burette and level-bottle N at the same height, note the position of the lowest point of the meniscus at the surface of the water, with refererence to the graduations of the scale. This gives the reading under atmospheric pressure, and subtracted from 100, gives the amount of absorption. Transfer the gas to the absorption tube by opening stop-cock H′, raising level-bottle N and lowering level-bottle M, and again treat with potassium hydroxide. Transfer to measuring burette and take the reading under atmospheric pressure. If this corresponds to the former reading, the absorption is complete; if not, more reagent must be added until two consecutive readings agree. It is seldom that one treatment does not suffice, but this precaution should be taken after each absorption. With the gas in the measuring burette, turn the stop-cock D′ so that it communicates with the drain V (position shown in Figure 4); open stop-cock B′ and add water through the funnel F′, rinsing all reagent from the tube. With the tube clean, turn stop-cock D′ to shut off the drain and connect the level-bottle and absorption tube; open stop-cocks H′ and M′ to the horizontal capillary, with outlets up, and raising level-bottle M, fill the absorption tube and capillary with water, closing stop-cocks M′, H′ and B′ as the water overflows from the exit N′ and the end A′ of the vertical tube. Transfer the gas to the absorption tube.

Determination of Illuminants. Fill the funnel F′ two-thirds full with water, and with a small dropping pipette add a few drops of bromine. Partly open stop-cock B′, allowing the bromine water to spread around the bulb and flow down the sides of the absorption tube. The tension of bromine being high, the tube will quickly fill with vapor, when the stop-cock B′ should be closed. Before transferring to the burette for measurement, add potassium hydroxide (emptying funnel of any bromine water remaining) to absorb the bromine vapors, and then transfer the gas to the measuring burette. Note the reading, which, subtracted from the previous one, gives the percentage of illuminants.

Determination of Oxygen. With the gas in the measuring burette, rinse the absorption tube and capillary well out with water and refill. Transfer the gas to the absorption tube and treat with the next reagent, potassium pyrogallate. Measure the amount of absorption in the measuring burette. This reading, subtracted from the last one, gives the percentage of oxygen.

Determination of Carbon Monoxide. Having rinsed the absorption tube and capillary of the last reagent and filled with water, transfer the gas from the measuring burette and treat with cuprous chloride. After using this, and previous to transferring the gas for measurement, add water to absorb the acid vapors. Transfer, and note the reading, which, subtracted from the last, gives the percentage of carbon monoxide. Especial care should be exercised to make this absorption complete.

(Continuation in next number.)

Fraternal

TRANSMISSION ASSOCIATION MEETING.

The following self-explanatory notice has been sent concerning the forthcoming third annual meeting of the Pacific Coast Electric Transmission Association:

> The third annual meeting of the Pacific Coast Electric Transmission Association will be held at the Cliff House, San Francisco, Cal., on June 20, 1899.
>
> The first meeting will be called at 1:00 p. m. At 6:30 a dinner will be served by the Association, which will be followed by informal discussions continuing during the evening.
>
> The second meeting will be called at 11:00 a. m., June 21, and continue at the pleasure of the convention. Accomodations will be found at the Cliff House for such as wish to spend the night there.
>
> The Executive Committee request from the members of the Association (both regular and associate) contributions of papers on subjects of interest to the transmission companies, and urge that immediate notice of subjects selected be sent to the office of the President, 175 Crocker Building, San Francisco, Cal.
>
> From the material already secured, an interesting and profitable convention can be assured, if properly supported by a large attendance from the transmission companies. Kindly assure the Executive Committee *at once* of your attendance at the convention.

Electro-Therapeutics

INCANDESCENT AND ARC LAMPS IN THERAPEUTY.

BRITISH contemporaries of both medical and electrical inclinations are extolling the merits of electric light baths, in which incandescent lamps are used as thermal generators. Certain special advantages have been claimed for them on the ground that the heat energy is from a source at a very high temperature, and is radiated rather than conducted, and also that the light given out by the lamps may have beneficial effects. The baths consist of wooden boxes or cabinets arranged for the reception of the patient, and fitted in with from 30 to 40 incandescent lamps and reflectors. It has been recognized from the use of the apparatus, that the effects are mainly due to radiant heat, and the action of radiant heat from a source at a high temperature is in contrast with that of the heat of lower grade employed in the hot room of a Turkish bath. For instance, the degree of perspiration obtained with an air temperature of 85° F. in the electric cabinet, is equal to that produced in a Turkish bath at 160° F. The diseases in which the treatment has been said to have been found beneficial are rheumatism, asthma, ænemia, neurasthenia, and obesity.

Experiments have also been made upon the therapeutic action of arc lamps, in which the patient is placed in a cabinet with two arc lamps arranged outside, so as to shine into the cabinet through a glass window. The patient is nude, wears dark spectacles, and reclines on a couch between the lamps, and it is claimed by Dr. Margaret Cleaves, in the *New York Medical Journal*, that immediately beneficial action has been obtained from the rays of the arc in chronic pulmonary complaints, such as phthisis, asthma, and bronchitis, while in a case of psoriasis and one of eczematous ulcer, the effect was prompt and good. Attention was first drawn to the subject from statements made as to good effects noted by workmen in electric welding works wherein cures were effected in 25 out of 38 cases, mostly neuralgia, sciatica, lumbago and the like, among the workmen. More extended observations are called for, and it is not unlikely that the arc lamp will take a place in therapeuty. Several independent writers have noted that the arc lamp, either by its light or the emission of ozone or other vapors, has a very decided disinfecting or deodorizing action upon noxious smells; thus an arc lamp set up in a dark basement near offensive closets, has served to dissipate all bad odor therefrom completely.

WIRE FOR RESISTANCE COILS.

German silver, platinum silver, and platinoid are the three alloys generally used for resistance purposes in electrical measuring instruments. Expressing their ingredients by weight, the alloys are as follows: German silver: copper, 4 parts, nickel, 2 parts, and zinc, 1 part; platinum silver: platinum, 1 part, and silver, 2 parts; platinoid: German silver, 49 parts, and tungsten, 1 part.

It is given on the authority of Dr. H. Bunte, of Carlsruhe, that while water gas generates only one-half the heat produced by a like volume of illuminating gas, this discrepancy does not make itself perceptible in the same proportion in the production of light in the Welsbach mantle, for the water gas burner, according to Strache, requires, for the candle hour, about two litres (0.07 cubic foot) of gas, thus substantially no more than illuminating gas in the ordinary Welsbach burner.—*The Gas World.*

TABLE OF CONTENTS.

Illustrated articles are designated by an asterisk (*); Editorials by a dagger (†); Passing Comment by a double dagger (‡), and Industrial by a section mark (§).

Electro-Therapeutics

Incandescent and Arc Lamps in Therapeuty........................ 84

Fraternal

Electric Transmission Association Meeting.......................... 84

Gas

Gas Engines in English Electrical Stations........................ 81
*Industrial Gas—II, by Frank H. Bates..... 82

Illumination

‡A "Joker" in Welsbach Lighting................. 80
Luminosity of a Nernst Lamp is Deceptive........................ 77

Physics

Measurement of Low Temperatures, by Walter H. Dickerson, M. E. 81

Transmission

†An Inexcusable Failure.. 79
Synchronous and Induction Motors, by Charles F. Scott............ 77
*The Ferraris-Arno Phase Transformer............................. 81
*The Kootenay-Rossland Power Transmission, by Geo. P. Low...... 69
†The New Transmissions of the West................................ 78

THE JOURNAL OF ELECTRICITY.

VOLUME VII. SAN FRANCISCO, JUNE, 1899. NUMBER 6.

The Kootenay-Rossland Power Transmission.

BY GEO. P. LOW.

[CONCLUDED.]

THE ROSSLAND SUB-STATION.

THE transmission lines enter the sub-station at Rossland through portholes lined with eight-inch terra cotta piping similar to those provided at the power house. As one enters the door of the sub-station the standard General Electric lightning arresters used are placed on a marble board in a corner at the left as shown in the floor plan appearing on page 86. The choke coils used are an innovation in that each consists of a core twelve inches or so in length turned in the center of a stick of kiln dried and well filled timber about five inches square, by from six to eight feet long. About this core insulated wire is wound until the space is filled so that the choke coil thus formed resembles an exaggerated form of spark coil with its terminals carried out to the respective ends of the timber on which it is wound, these timber ends being strapped to the top of high tension insulators through which the choke coil is cut into the line. Such choke coils are placed in every line, not only at the sub-station but at every power service. At present the Rossland sub-station contains but six 250-kilowatt step-down transformers, although six others, each of equal capacity, are being installed with the new 1500-kilowatt generator. The line wires are carried to the high tension switchboard at the rear of the station on high tension insulators supported by framings that hang from the roof girders, and the usual facilities are provided to afford safety and celerity in the handling of both the high and low tension sides of the transformers. These latter are of the same type and size as those installed at the power house, with the exception that the primaries take either 9600 or 16,600 volts, according to whether connected in delta or Y, while the secondaries deliver 2200 volts in three-phase current, which is the potential used on all the lighting and power distributing circuits in and about Rossland.

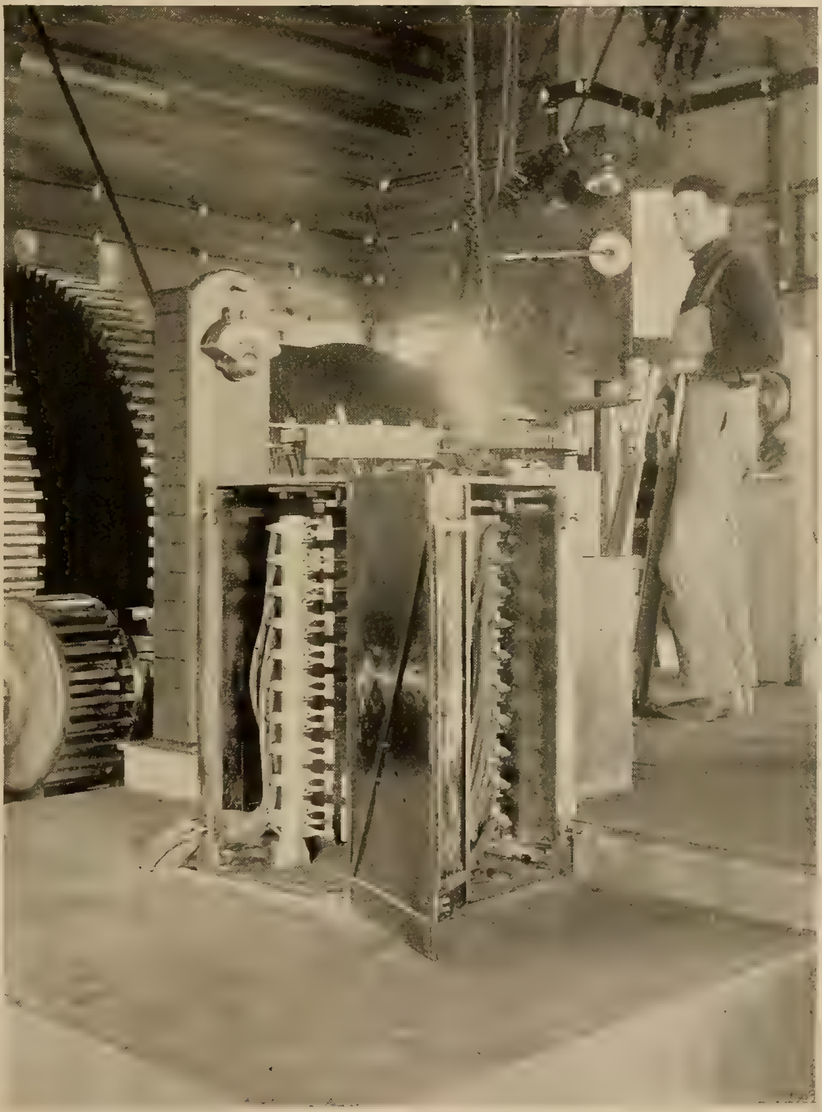


FIGURE 22.—VIEW OF CONTROLLER FOR INDUCTION MOTOR AT WAR EAGLE MINE.

Here may be explained, through the accompanying cuts presenting the floor plan, end and side elevations of the sub-station at Rossland, the very meritorious method which the electrical engineer of the West Kootenay company has devised for applying the air blast to the transformers at the power house and at the Rossland sub-station. As in the power house, the blast is supplied by three sixty-inch blowers each driven by belting from a two horse-power 100-volt induction motor. Instead of carrying this air blast to the transformers through small air ducts as is usually done, the engineer of the Kootenay plant has provided subways large enough for a man to enter and move about in. The manner in which the blowers supply air to these subways is shown in the end elevation of the sub-station, while the subways themselves, as is shown in the side elevation, extend in line with and directly under each row of step-down transformers. The idea of this arrangement will be understood when it is stated that each week the transformers are cut out of service one by one and the air ducts in them are each and every one examined and cleaned by a man who enters the subway in order that he may have access to the lower end of the air ducts in the transformer. His work in cleaning the transformers is facilitated by the use of compressed air, which is obtained in both the power house and the sub-station from a single drill compressor driven by an induction motor. It is safe to say that so long as this method of transformer examination and cleaning is faithfully carried out the Kootenay transmission will never lose a transformer from the choking of its air ducts. Slides for regulating the amount of air to be delivered to each transformer are provided and of course the subway is always air tight and the man who cleans the transformers is under the increased atmospheric pressure of the air blast while at his work.

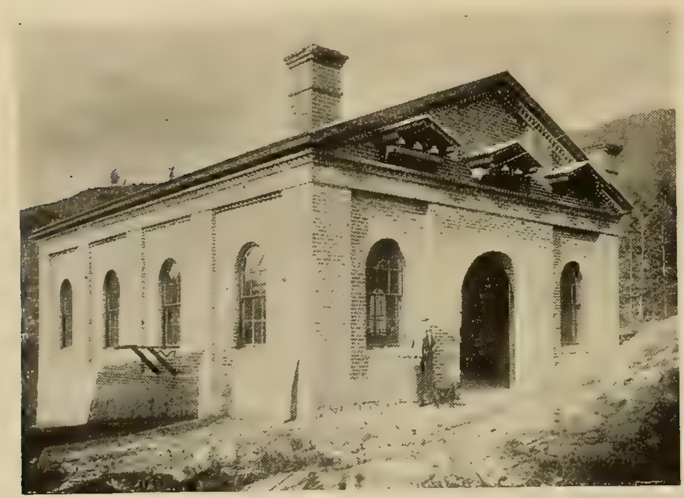


FIGURE 14.—THE SUB-STATION AT ROSSLAND.

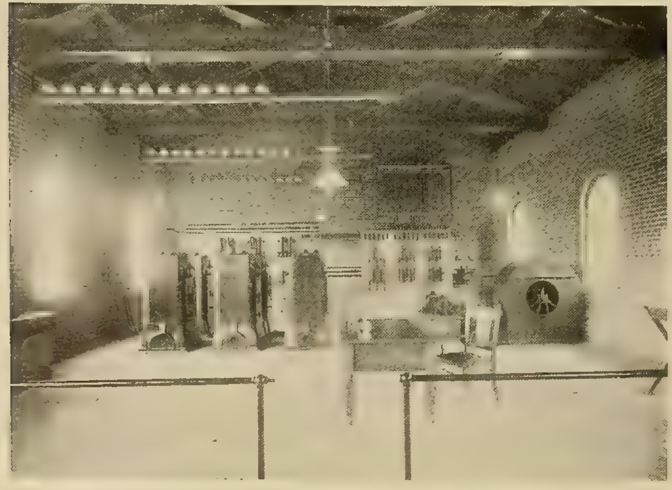


FIGURE 15.—INTERIOR OF SUB-STATION AT ROSSLAND.

The photograph showing the interior of the sub-station was taken shortly after the plant started operations and since then important additions have been made. The distributing switchboard at the right in the rear has had new panels added to it to accomodate other circuits. The third blower has been added and immediately in front of it, as shown in the floor plan of the sub-station in Figure 16, has been placed the induction regulator by means of which the potential of the outgoing lighting service is controlled by the sub-station attendant independent of the power house.

This is a new device of the General Electric Company, bearing the designation "type I. R. T. class 4–20–60 form A." It is wound for seventy amperes per phase at 2200 volts and has a range of 220 volts in either direction. It is described as consisting of an induction motor with a vertical shaft, which is connected through bevel and worm gearing to the shaft of a pilot motor placed on top of the case so that the rotor of the induction regulator may be made to turn a given arc in either direction and in so turning raises or lowers the electromotive-force in the primary mains passing through the stator windings as desired. The pilot motor is manipulated from a simple double-pole, double-throw reversing switch placed on the switchboard; and this motor too is an induction motor. All details of this novel regulator together with those of the limiting switch placed thereon are given in Figure 20. At present this regulator is used only on the lighting circuits, nor is its use contemplated on the power service.

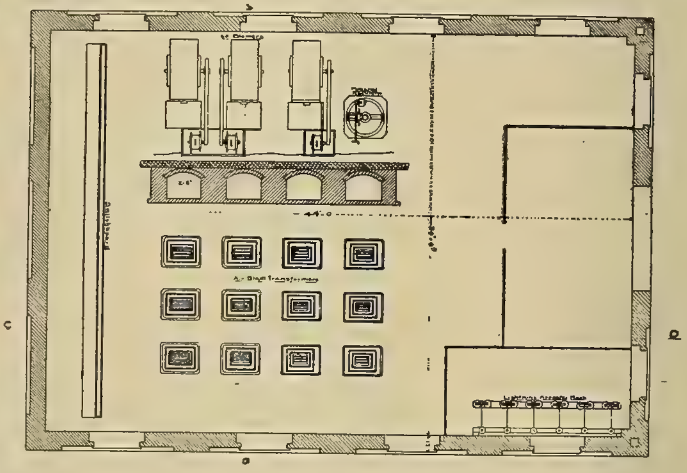


FIGURE 16.—FLOOR PLAN OF SUB-STATION AT ROSSLAND.

All the electric lighting in Rossland, in both arc and incandescent services, is rendered from alternating circuits, and indeed the only use to which direct currents are put in the Kootenay plant is for the excitation of generators and synchronous motors. The electric lighting load reaches a maximum of nearly 400 horse-power. Enclosed alternating arc lamps are used exclusively and these are burned from the 110-volt commercial circuits. The ultimate distribution is on the Edison three-wire system through the use of type H transformers taking either 1400 or 2080 volts on the primary and delivering

230 volts across the outsides of three-wire service. The utmost care has been exercised in preserving the balance on the three-wire distribution circuits as well as in balancing the primaries of the commercial transformers on the three-wire, three-phase, 2200-volt circuits, and this balancing has been carried out so well that it has never been observed that the phases of the 2200-volt circuits have been more than 10 amperes out of balance.

As stated heretofore, the principal interest in the Kootenay-Rossland transmission centers in its application of electric power for mining and milling purposes, the most notable installations being in the properities of the War Eagle Mining and Development Company, the British Columbia Bullion Extraction Company, the British American Corporation, and the Gertrude, Big Three and Iron Mask mines. These six properties alone consume about seventeen hundred horse-power in the operation of hoists, compressors, crushers, conveyers, ventilating blowers and in electrolytic work. The bulk of this power is delivered by induction motors, for as a general rule, synchronous motors have been applied only to the driving of compressors.

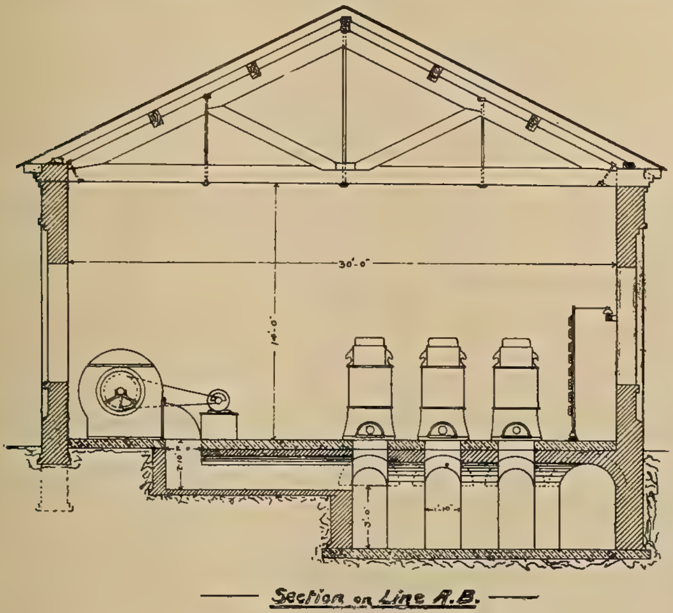


FIGURE 17.—END ELEVATION OF SUB-STATION AT ROSSLAND.

The initial illustration gives a general view of the controller of the War Eagle hoist which will be seen to be a standard General Electric induction motor. It is a three-phase equipment operated at 2300 volts, has twenty-four poles and delivers three hundred horse-power at three hundred revolutions per minute. Its technical designation is, therefore, "I 24–300–300 form A." The rotor shaft is geared to a Ledgerwood type double drum hoist through double reduction gearing, having a ratio of reduction of 300 to 40. The War Eagle shaft is at present down a little beyond the 600-foot level and the maximum load raised amounts to eight tons including the load, cage and rope, the speed being 720 feet per minute for this load.

Interest of course centers in the method of speed control, each technical detail of which is fully shown in the accompanying photographs and drawings. Secondary control is used exclusively; that is, no effort whatever is made to control the primary current, while the secondary current, or that induced in the rotor circuit, is varied by the introduction of external resistance. The controller proper, shown in Figure 22 is a duplex one inasmuch as the movement of the controller handle manipulates both the primary and secondary circuits of the motor, the former for making, breaking and reversing and the latter for the control of the variable external resistance. The controller on the high tension or stator side operates in a bath of mineral oil. The secondary windings are led to three collector rings placed on the shaft with the rotor, and upon these rings bear carbon brushes which cover about 90 degrees of the surface of the rings, this being a necessary procedure because of the heavy ampereage to be taken off. The maximum secondary electromotive force obtained is in the neighborhood of seventy volts. From the rotor brushes the current is carried to the low tension side of the controller through which resistance may be cut in or out of the rotor windings in ten steps. The resistance consists of cast iron grids arranged upon a large slate resistance board as shown in Figures 25 and 26. With the maximum load of eight tons gross at a speed

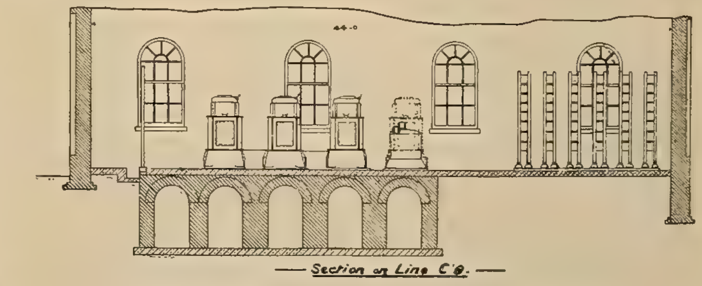


FIGURE 18.—SIDE ELEVATION OF SUB-STATION AT ROSSLAND.

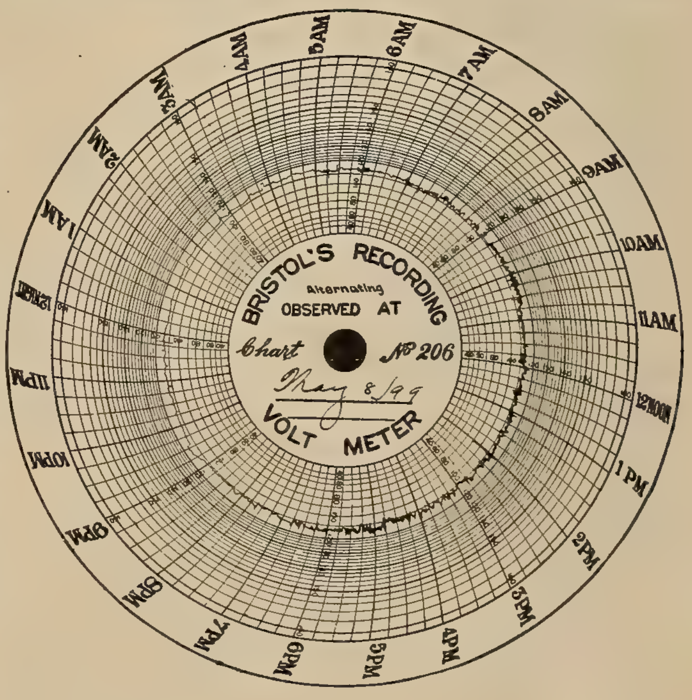


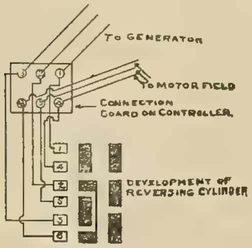
FIGURE 19.—TYPICAL CHART OF VOLTAGE REGULATION.

of 720 feet per minute the current reaches a maximum of 110 amperes per phase, dropping back to 90 amperes as the load decreases by the reason of the cage nearing the surface. With a load of men the maximum current is 70 amperes per phase.

The principle under which variable speed is attained in the operation of this induction motor is found in the fact that while in the synchronous motor, exact synchronism between the motor and generator must always be maintained, yet the induction motor is so constituted as to be nearly independent of any magnetic slippage that may exist between its stator and rotor. When under full speed the motor is practically in synchronism with the generator, but with the generator speed constant a variable speed in the motor is best attained by the introduction of methods that will provide variable slippage as desired, for the greater the slippage the slower will be the speed of the rotor. The equipment at the War Eagle hoist is so controlled that the speed of the motor may be varied from forty revolutions or less per minute to its full speed of three hundred revolutions.

As will be seen in Figure 22, the high and low tension controllers are geared together, this being done in such a manner that both are actuated at proper intervals by the manipulation of a single controller handle. The only function of the electrical equipment is that of hoisting, for as the cages are balanced one against the other it is the rule that power is applied for either direction of rotation. Braking is done through the application of band brakes by means of the hand levers shown in the illustration on the next page.

The subjoined diagram of circuit connections shows the development of the reversing cylinder as applied to the high tension controller. The head board of this controller has six terminal lugs, those numbered 1, 2 and 3 being for the service leads, while those numbered 4, 5 and 6 are carried to the motor. The controller applies the full line potential of 2300 volts to the stator, and it serves not only as a make and break switch but also as a pole changer for reversing. The short circuiting of terminals 1 to 4, 2 to 6, and 5 to 3, causes a given direction of rotation, while the short circuiting of terminals 1 to 4, 2 to 5, and 3 to 6 causes an opposite direction of rotation, all as shown in the attached circuit diagram. Mineral seal or any high grade transformer oil may be used for the bath for this high tension controller, which gives perfect satisfaction in operation.


To GENERATOR
To MOTOR FIELD
CONNECTION BOARD ON CONTROLLER
DEVELOPMENT OF REVERSING CYLINDER

The connections of the circuits by means of which external resistance is cut in and out of circuit with the rotor windings through the low tension controller are outlined in Figure 23, and in Figure 27 is given the assembly diagram of the stationary cast iron resistance as mounted on the slate resistance board shown in front and back views in Figures 25 and 26. It must be understood that the terminals at the bottom of the slate panels appearing in the upper portion of Figure 23 are the same as those shown at the bottom of Figure 27. The resistance strips shown so clearly in Figure 26 consist of cast iron grids, each in three waves, having a sectional area of about ⅛ by ⅝ inches and which have a running length of about sixty inches. These grids stand out from the board about 14 inches and they are in 23 vertical rows by 18 horizontal ones, and while the average cross section is as given, it varies slightly above and below that figure according to the ampereage carried.

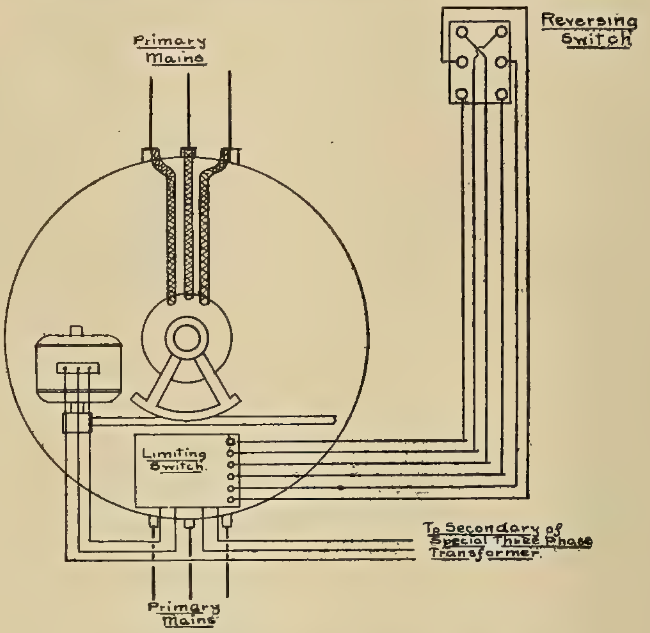


FIGURE 20.—CONNECTIONS OF INDUCTION REGULATOR.

Reverting to the scheme of low tension controller and resistance switch-board connections outlined in Figure 23, the leads from the slip rings on the shaft of the motor are carried to three sets of contact plates placed on the controller cylinder in ordinary arrangement, and upon these contact plates play the contact fingers which carry current successively to the resistance. Three posts are erected in the controller, each of which carries a set of ten contact fingers and two of the sets are shown in Figure 22. As stated, the maximum potential broken by the low tension controller is about seventy volts and the sparking is inconsequential.

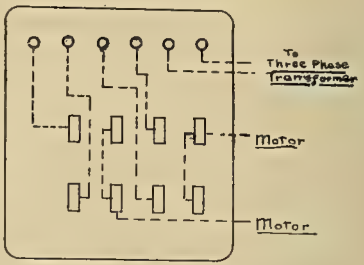


FIGURE 21.—CONNECTIONS OF LIMITING SWITCH.

One who is interested could spend hours in watching the operation of this hoist. It is easily handled by one man who finds himself with much less to do than has the motorman on an electric railway. In fact, the operation of the War Eagle hoist finds greater resemblance to street railway practice than one would imagine. The controller is manipulated with the same ease and celerity that attends the handling of a street railway controller, and it is more simple than the modern street railway controller in one regard, and that is the fact that reversal is accomplished in the War Eagle controller by the moving of the controller handle in a reverse direction rather than in the throwing of a special lever. At times when men are on the cage the hoist is "kicked" along by the momentary application of power to the motor, which enables it to be run at much slower speed even than that possible with the controller on the first notch. At other times in hoisting ore, a dead load of five tons of which is almost always carried, the motor will be brought up to speed in a very few seconds and this without any abnormal inrush of current, for, as stated, during the writer's observations of the operation of the equipment under all conditions of service the motor intake did not exceed 110 amperes per phase. The motor has an efficiency of 92 per cent. and a full load power factor of 88 per cent., while at the slowest speed the power factor may drop to possibly between sixty and seventy per cent., but of this last statement no direct data is available at present. Current for the operation of the entire War Eagle equipment is sold by contract; *i. e.* on flat rates.

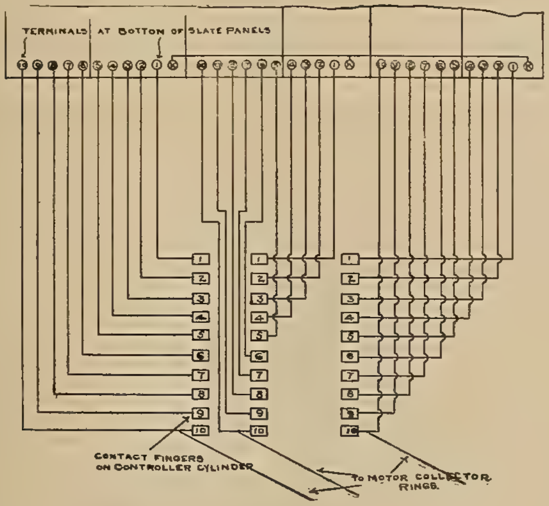

TERMINALS AT BOTTOM OF SLATE PANELS
1
2
3
4
5
6
7
8
9
10
CONTACT FINGERS ON CONTROLLER CYLINDER
TO MOTOR COLLECTOR RINGS

FIGURE 23.—CONNECTIONS OF INDUCTION HOIST MOTOR AND CONTROLLER.

The next feature of interest in the electrical installation at the War Eagle mine is found in the 300-kilowatt synchronous motor operating the 40-drill compressor illustrated in Figure 28. Three-phase current at 2300 volts is applied to this motor which runs at 200 revolutions per minute. It is of the revolving armature type, has thirty-six poles and, consequently, bears the designation "A P 36–300–200." A General Electric multipolar exciter, not shown in the illustration, is driven from a large pulley on the free end of the motor shaft, and this exciter has an output of nine kilowatts at 125 volts when operated at 1450 revolutions per minute. The compressor, which is of a double duplex type, is driven through independent ropes applied direct as shown in the illustration.

FIGURE 25.—FRONT VIEW OF EXTERNAL RESISTANCE BOARD.

The method originally installed for starting the synchronous motor is also shown in the illustration given and it consisted of a thirty horse-power induction motor belted

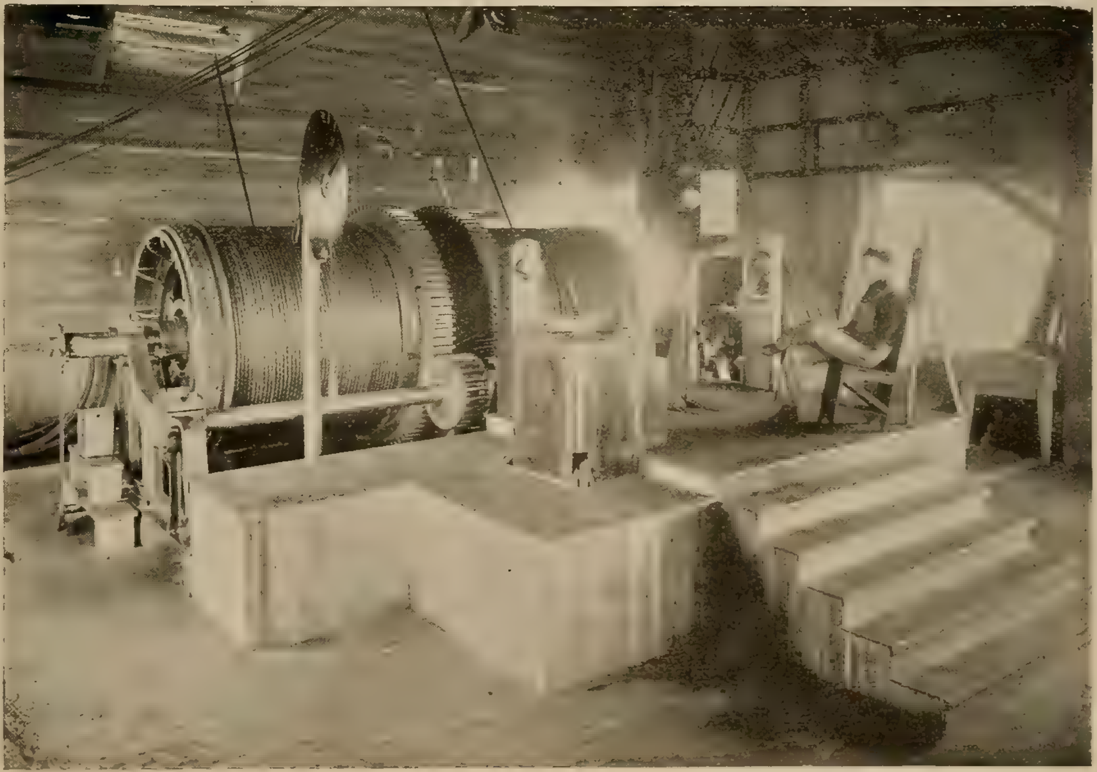


FIGURE 24.—GENERAL VIEW OF INDUCTION HOISTS AT WAR EAGLE MINE.

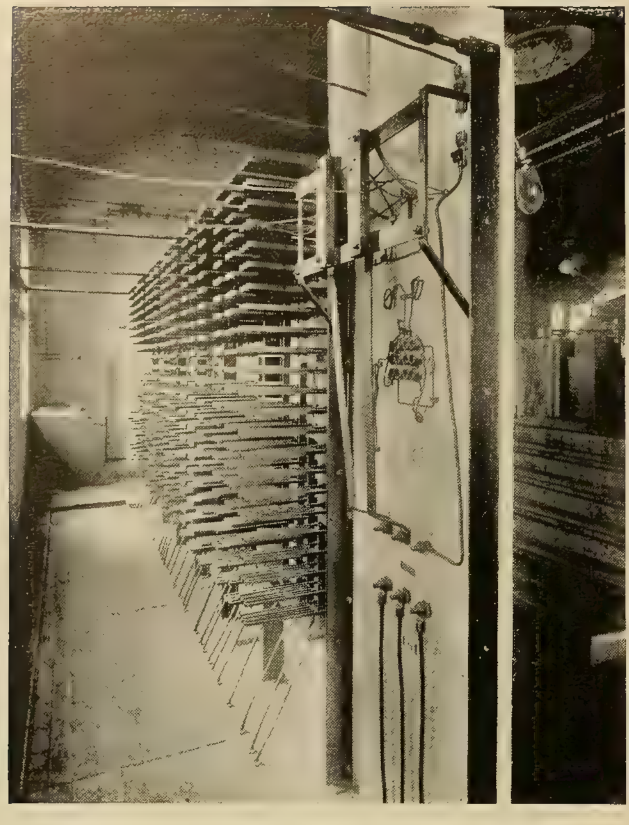


FIGURE 26.—BACK VIEW OF EXTERNAL RESISTANCE BOARD.

to a counter shaft through a friction clutch, this shaft carrying a spur gear by means of which the armature was brought up to speed. It can not be said that this equipment has been satisfactory, although it is in practical operation. The difficulties in its use rest first in the fact that in bringing the armature up to synchronism the compressor must, as well, be brought up to speed; and second, the 30 horse-power motor is too small for the duty required. It takes most exactly eight minutes to bring the motor up to synchronism, in doing which the 30 horse-power induction motor delivers from 120 to 130 horse-power, and, incidentally, has its temperature raised to a point somewhere above that conducive to a ripe old age. Although the small motor was still in service at the time of the writer's visit to the mine, it was shortly to be replaced by one having more than double its capacity. It should be stated in justice to the engineer of the Kootenay company that the starting device here discussed was not of his design or sanction. With the exception of the time consumed in starting, the equipment gives the best of satisfaction. A number of small motors ranging up to 20 horse-power in capacity are used in and about the War Eagle mine for ventilating purposes, driving conveyors, etc., and all these motors are of the induction type except that on the compressor.

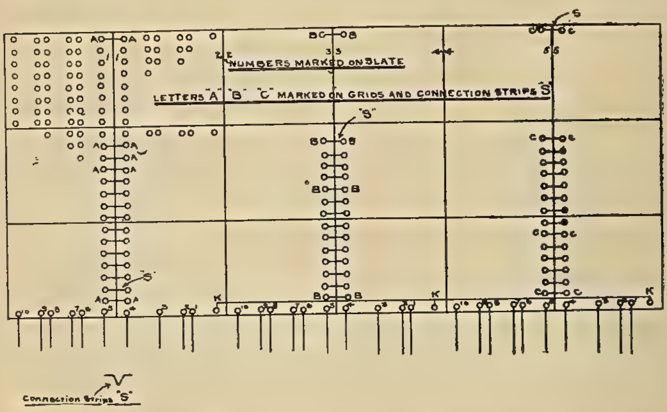

NUMBERS MARKED ON SLATE
LETTERS "A" "B" "C" MARKED ON GRIDS AND CONNECTION STRIPS "S"
Connection Strips "S"
S
AO
OA
BO
OB
CO
OC
K

FIGURE 27.—ASSEMBLY DIAGRAM OF STATIONARY CAST IRON RESISTANCE.

At the Iron Mast mine is a 75-kilowatt "S. K. C." synchronous motor, made by the Royal Electric Company of Montreal. It is a two-phase motor, with connections altered for three-phase service, and is started through an "S. K. C.'

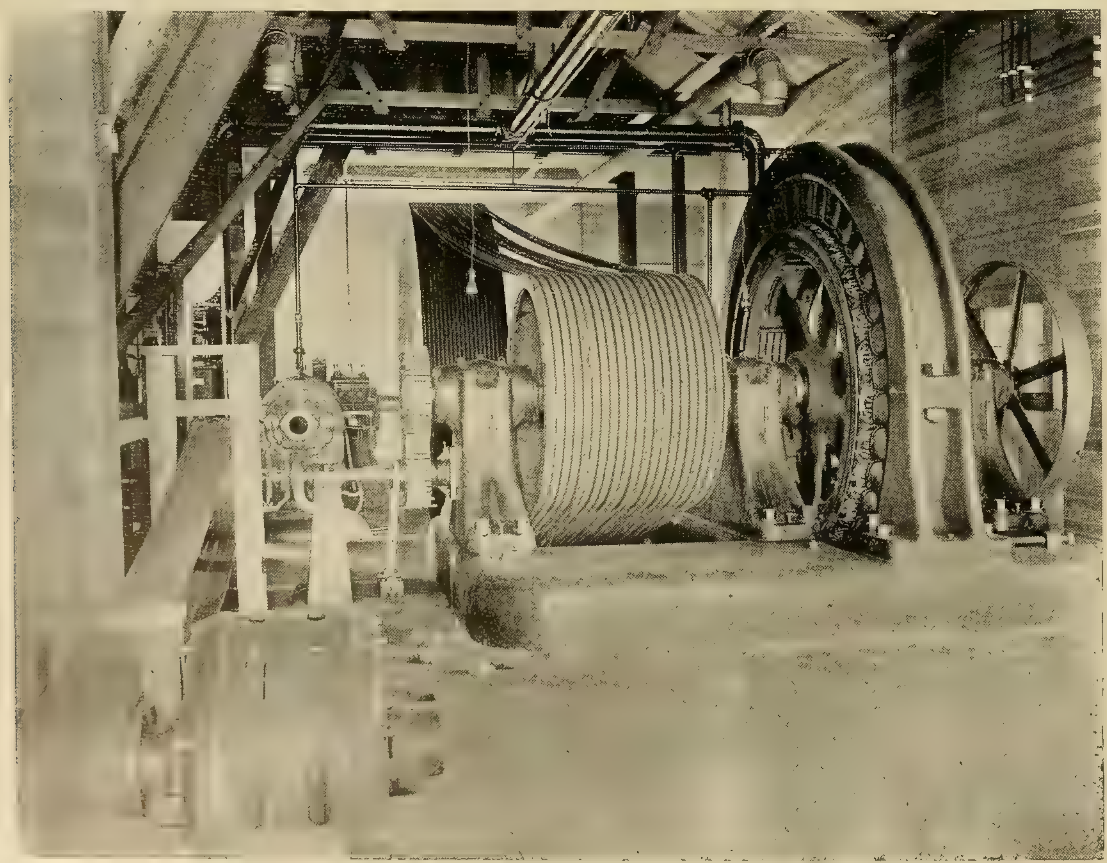


FIGURE 28.—VIEW OF 400 H.-P. SYNCHRONOUS MOTOR, DRIVING 40-DRILL COMPRESSOR AT WAR EAGLE MINE.

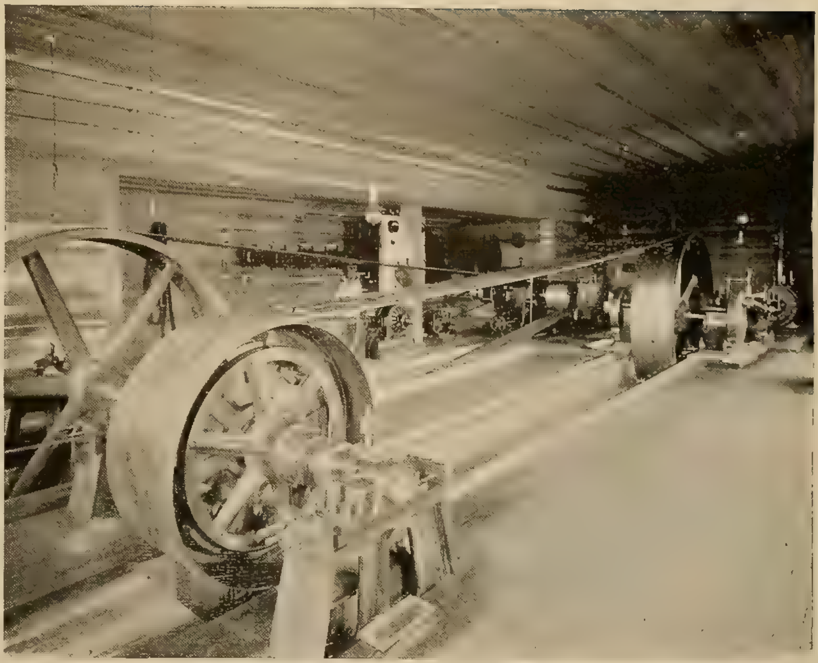


Figure 29.—Stanley 100 horse-power synchronous motor, driving 10-drill compressor at the Iron Mask mine.

induction motor and water rheostat, both of which appear in the illustration shown in Figure 29. The water rheostat consists of three fan-shaped blades plunged edgewise into a three-compartment tank of water, thus enabling the water resistance cut into each leg of the three-phase circuit to be varied according to the depth of immersion. The 75-kilowatt motor is belted to a jack-shaft in the manner shown, which drives two double-acting compressors having a combined capacity of ten drills. This is the only Stanley equipment on the West Kootenay circuit, and its service is most reliable.

In the Big Three mine is a 75-kilowatt General Electric synchronous motor, driving a seven-drill compressor in the manner shown in Figure 30, while at the Gertrude mine is a 50 horse-power General Electric induction motor operating a hoist. The British Columbia Bullion Extraction Company has one 50 horse-power induction motor driving a rock breaker, and one 75-kilowatt synchronous motor operating all machinery about the mine, including generators for electrolytic work.

These motors, as well as all others referred to hereafter, are of Canadian General Electric manufacture. In the properties of the British-American Corporation are four 150 horse-power induction motors, each operating a double drum hoist through equipments which are in every way similar to those at the War Eagle mine. All underground work in and about Rossland is operated at 220 volts. Aside from mining work, the principle power installation is that of the general machine shop of Cunliffe & Abblett, where a 50 horse-power induction motor is installed.

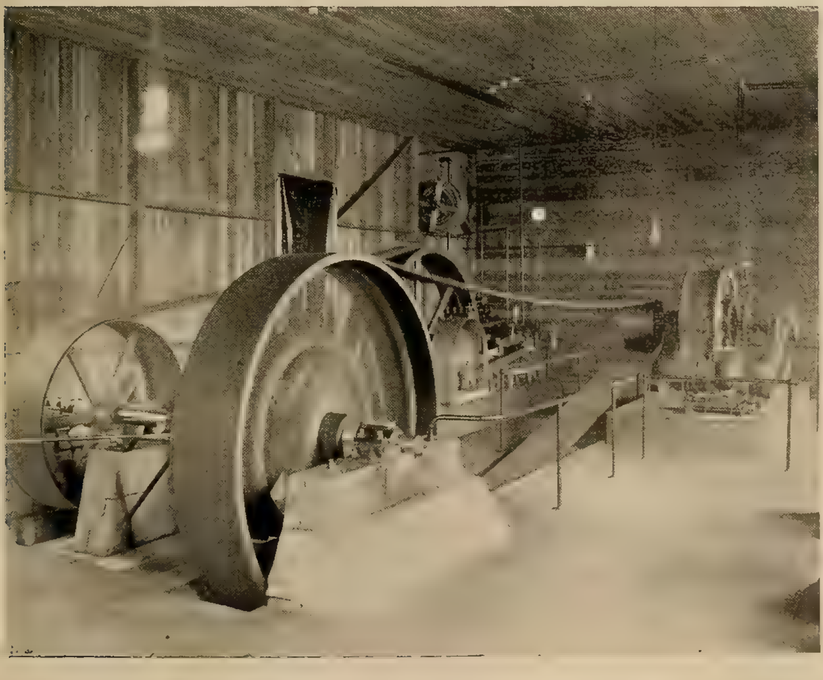


Figure 30.—100 horse-power synchronous motor, driving seven-drill compressor at the Big Three mine.

There are many small motors ranging from one to five horse-power in size for the furnishing of light power in different industries in Rossland.

One of the most interesting points to be brought out by the Kootenay-Rossland transmission is the demonstration of the fact that the operation of synchronous and induction motors in large units for the driving of hoists and compressors will not necessarily create serious disturbance in the voltage of the distribution circuits, provided high voltage, ample fly-wheel effect and capacity prevails. During daylight the power and lighting circuits are operated in parallel, although they are separated and operated independently from the power house by night. The War Eagle hoist, however, is operated on an independent circuit by day, but at night it is cut into the power circuit at the Rossland sub-station. The result of this arrangement is shown in the reproduction of the recording voltmeter chart shown in Figure 19, which is that of the lighting circuit. From 6:45 p. m. to 5:00 a. m. the chart shows the regulation of the lighting circuit when on an independent line from the power house. At 5:00 a. m. the War Eagle hoist is taken from the power circuit and put on an independent line to the power house and the remaining power load is coupled in with the lighting load and carried on the second line to the power house. The voltmeter curve therefore, from 5:00 a. m. to 6:45 p. m. shows the regulation of the plant when all power with the exception of that for the War Eagle hoist is in parallel with the day lighting load. The chart given is that for an ordinary day, and, indeed, the charts run so evenly from day to day that each almost duplicates the other. The day in question there were in operation from 5:00 a. m. to 6:45 p. m. three 100 horse-power synchronous motors with an average load of 280 horse-power on compressor work; five 50 horse-power induction motors with an average load of 210 horse-power on the same, 3 of which were on hoists; three 30 horse-power induction motors with an average load of 76 horse-power, and one 40 horse-power induction motor carrying an average load of 32 horse-power. The lighting load consisted of 300 horse-power, which is high in proportion to the night lighting load because of the heavy 24-hour load carried. The report from the generating station for the same day shows that the variation reached 108 amperes at 110 volts, or an approximate variation of 205 horse-power, considering which the regulation is remarkably good. The secret of this is stated to lie in always maintaining a high voltage in relation to the motor ratings, with ample generator and water wheel capacity.

The conception and commencement of the work on the remarkably interesting transmission of the West Kootenay Power and Light Company, Limited, are largely due to the efforts of Sir Charles Ross, Bart., and Mr. Oliver Durant. The charter was obtained in the name of Mr. Patrick A. Largey, president of the Center Star Mining and Smelting Company, Oliver Durant, manager, and C. R. Hosmer, manager of the Canadian Pacific Railway Company's telegraphs, and it was afterward transferred to the West Kootenay Power and Light Company. Preliminary surveys were made early in 1897, but it was in July of that year that the location of the plant was definitely settled and actual construction begun. The plans of the company contemplate the ultimate utilization of the entire three falls.

The present Board of Directors of the West Kootenay company are Sir Charles Ross, Bart., Balnagown, Scotland, President; Mr. W. M. Doull, Montreal, Vice-President; Mr. J. M. Smith, Rossland, Secretary and Treasurer; Mr. L. A. Campbell, General Manager, and Messrs. Oliver Durant, Rossland, C. R. Hosmer and Frank Paul, Montreal, and T. G. Blackstock, Rossland. The entire plant is under the personal management of Mr. L. A. Campbell, to whom great credit is also due for the able administration of the position of electrical engineer which he has filled in addition to his duties as general manager. The line was erected under the supervision of Mr. B. O. Boswell, so well known in California as superintendent of construction of the lines of the Folsom-Sacramento, Fresno, and other transmissions.

Personal

Mr. A. M. Hunt has accepted the responsibilities of the general managership of the Independent Light and Power Company, San Francisco, in addition to his position of engineer-in-chief of the same concern.

Mr. T. E. Theberath will hereafter devote his entire time to the Yuba Electric Power Company, of which he is electrical engineer, to accept which position he has resigned from the electrical engineership of the Pacific Coast agency of the Stanley Electric Manufacturing Company.

Gas

INDUSTRIAL GAS.—III.

BY FRANK H. BATES.

[THE ELLIOTT APPARATUS—CONTINUED.]

THE gas residue, sometimes termed gas rest, or portion remaining after the absorbable constituents have been removed, may consist of hydrogen, methane, and nitrogen.[*] The explosion or combustion tube is employed for their determination, since in their combination with oxygen there is a resulting contraction, which, together with the volume of carbon dioxide formed, affords sufficient data for the computation of the volume burned.

Operation. The gas residue is retained in the measuring burette; with the stop-cock H' (Figure 4[†]) closed to the burette B and open to the horizontal capillary, adjust stop-cock M' so that it communicates with the explosion burette, absorption tube and outlet N'. By raising the level-bottles M and P, force any air from the capillary, completely filling the entire apparatus with the exception of the measuring burette containing the gas residue, with water, when close stop-cock M' to both burette and capillary, the outlet toward the right. Raise level-bottle N, turn stop-cock H' so as to bring the outlet open to the capillary in the direction of the explosion burette, lower level-bottle P, open stop-cock M' so that it makes connection between the explosion and measuring burettes (position shown in cut), and admit to the former some 15 cubic centimeters of the residual gas, by the graduations on the explosion burette. Close stop-cock H' by bringing to the position with the outlet in the direction of the explosion burette just closed, and after waiting one minute for the walls to drain, raise level-bottle P so that the level of the contained water will correspond to that in the explosion burette, and note the reading, giving the volume of the sample of residual gas under atmospheric pressure. Since the determination of the constituents of the residual gas is by means of combustion or chemical union with oxygen, sufficient of the latter must be admitted to supply the hydrogen and methane, the nitrogen remaining inert. Hydrogen requires one-half its volume of oxygen for complete combustion, and methane requires twice its volume, consequently, with an approximate knowledge of the amounts of these constituents present, it is a simple matter to decide upon the quantity of oxygen required, taking care to admit in excess.

With but a knowledge of the kind of gas under examination, whether coal, water, or producer gas, etc., one will be sufficiently guided after a little experience. The oxygen is admitted partly as free air, (air is about 22 per cent. oxygen by volume), and partly as pure oxygen. Generally speaking, for illuminating gas the air used should equal the volume of the gas sample. This may be admitted through the stop-cock T' at the lower end of the explosion burette, but more conveniently through the capillary N′ and stop-cock M′ by expanding the gas in the explosion burette by lowering level-bottle P. After admitting the air, make connection between the end U′ of the projecting capillary and the supply of oxygen.* Open stop-cock T′, admitting sufficient oxygen to make a total gas volume of about 75 cubic centimeters, when close stop-cock T′ and raise and lower level-bottle P, causing the gas to become thoroughly mixed, also dislodging any oxygen caught in the capillary above the stop-cock T′. Wait one minute for the burette walls to drain, then measure the total gas volume under atmospheric pressure. Dislodge any water adhering to the ends of the platinum wires by tapping the tube slightly. Lower the level-bottle P as far as possible to expand the gas, thus tending to render the explosion less severe. With all precautions there is a possibility of fracture at this time; it is therefore best not to expose the eyes. Make connection to the induction coil and battery, closing the circuit, causing a spark to pass between the points of the wires, thereby igniting the gas, which gives a sharp click.

---

[*] Traces of carbon monoxide and ethane and their determinations will be treated under "Special Schemes" in a later issue.

[†] See The Journal of Electricity, May number.

Allow the heat of the combustion to be absorbed by the circulating water in the jacket and then take the reading of the gas volume under atmospheric pressure. This, subtracted from the reading of total gas volume taken before the explosion, gives the contraction, which, for future reference, we will call C. Now raise level-bottle P, lower level-bottle M, and noting that the horizontal capillary and absorption tube are filled with water, transfer the products of combustion from the explosion burette to the absorption tube, where treatment with potassium hydroxide will absorb the carbon dioxide formed. After treatment with the absorbent, transfer back to the explosion burette, and, after waiting one minute for the walls of the burette to drain, measure, under atmospheric pressure, the amount of absorption. Let the amount, which equals the carbon dioxide formed, be called D. We now have sufficient data to determine the percentage of hydrogen and methane directly, and the nitrogen by difference.

The chemical reaction of hydrogen with oxygen is expressed by the following equation:

$$\underset{\text{Hydrogen}}{H_2} + \underset{\text{Oxygen}}{(O_2)_{\frac{1}{2}}} = \underset{\text{Water}}{H_2O} \quad \text{(Equation 1)}$$

One volume of hydrogen unites with one-half volume of oxygen, forming water, which, in changing from a gaseous to a liquid form, contracts so as to be of no appreciable volume, hence its volume may be neglected; we have then, 1 volume + ½ volume, or 1½ volumes contracting to zero volumes; or, the amount of contraction equals 1½ volumes, which is 1½ times the amount of hydrogen burned. ($1\frac{1}{2}H$).

The reaction of methane with oxygen is expressed by the equation:

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Oxygen}}{(O_2)_2} = \underset{\text{Carbon Dioxide}}{CO_2} + \underset{\text{Water}}{2H_2O} \quad \text{(Equation 2)}$$

One volume of methane uniting with two volumes of oxygen, forming one volume of carbon dioxide and water. As before, the water volume is neglected, hence we have 1 volume + 2 volumes, or 3 volumes; contracting to 1 volume, or the amount of contraction equals 2 volumes, which is 2 times the volume of methane burned. ($2CH_4$). There is one volume of carbon dioxide formed for each volume of methane burned, or $CO_2 = CH_4$.

Collecting from equations 1 and 2, we have

$$C = 1\tfrac{1}{2}H + 2CH_4 \quad \text{(Equation 3)}$$
$$D = 1CH_4 \quad \text{(Equation 4)}$$

in which C = the total contraction resulting from the combustion of the residual gas, and D = the carbon dioxide formed.

C, the contraction, is known as measured in the explosion burette, also D, the carbon dioxide formed, the amount of which was determined by absorption with potassium hydroxide; substituting for CH_4 in equation 3, its value D, from equation 4, we have

$$C = 1\tfrac{1}{2}H + 2D, \text{ or, } H = \frac{C - 2D}{\frac{3}{2}} = \frac{2C - 4D}{3} \quad \text{(Eq. 5)}$$

By substituting for D in equation 4, and for D and C in equation 5, their values, the per cents of methane and hydrogen become known.

The sum total of the per cents so far determined, subtracted from 100, gives the percentage of nitrogen. An example will serve to illustrate the entire proceeding:

Analysis of Coal Gas. A two-liter bottle of water was first saturated with the gas to be examined. The level-bottles and apparatus were then filled with the prepared water, expelling all air. A little more than 100 cubic centimeters of sample gas was drawn into the absorption tube, and afterward transferred to the measuring burette, where exactly 100 cubic centimeters, measured under atmospheric pressure, was retained, the excess being expelled by filling the apparatus with water from the level-bottles.

Gas then transferred to the absorption tube, where it was treated with potassium hydroxide, the first reagent.

Gas returned to the burette, and, after waiting one minute for drainage of walls, measured under atmospheric pressure, giving a reading of 99.5. This, subtracted from 100, gave the percentage of carbon dioxide:

$$100 - 99.5 = 0.5, \text{ or, } CO_2 = \tfrac{1}{2} \text{ of 1 per cent.}$$

The absorption tube was drained of the reagent, rinsed, and refilled with water. Gas then transferred to the absorption tube and treated with bromine water, the second reagent. As soon as the absorption was complete, potassium hydroxide was added to absorb the bromine vapors formed. Gas then returned to the burette and measured under atmospheric pressure, giving a reading of 95.5. This, subtracted from the previous one, 99.5, gave the per cent. of illuminants:

$$99.5 - 95.5 = 4, \text{ or, illuminants, 4 per cent.}$$

The absorption tube was then drained of the reagent rinsed and refilled with water.

---

*The oxygen may be prepared by heating a mixture of four parts, by weight, of potassium chlorate and one part of manganese dioxide, in a generator supplied for this purpose, and collecting in a gas holder in which the gas should be put under a slight pressure.

Gas then transferred to the absorption tube and treated with potassium pyrogallate, the third reagent.

Gas returned to burette and measured under atmospheric pressure, giving a reading of 95. This, subtracted from the previous one, 95.5, gave the percentage of oxygen:

$$95.5 - 95 = 0.5, \text{ or, } O = \tfrac{1}{2} \text{ of } 1 \text{ per cent.}$$

The absorption tube was drained of the last reagent, rinsed, and refilled with water.

Gas then transferred to the absorption tube and treated with cuprous chloride, the fourth reagent. Afterwards water was added to absorb the acid vapors and wash down the curdy, white precipitate of cuprous chloride.

Gas returned to burette and measured under atmospheric pressure, giving a reading of 89. This, subtracted from the previous one, 95, gave the percentage of carbon monoxide:

$$95 - 89 = 6, \text{ or, } CO = 6 \text{ per cent.}$$

The absorption tube was drained of the last reagent, rinsed, and refilled with water.

A portion of the gas now remaining, termed the residual gas, was transferred to the explosion burette, and on measuring was found to be 18 cubic centimeters. To this was added about 15 cubic centimeters of air and then oxygen sufficient to bring the total volume to 80 cubic centimeters, all measured under atmospheric pressure. By raising and lowering the level-bottle these gases were thoroughly mixed. A slight tapping dislodged the water adhering to the points of the platinum wires. The gas mixture was expanded by lowering the level-bottle as far as the rubber tubing would permit, thereby lessening the intensity of the explosion. On closing the circuit a sharp click was heard, giving assurance that the explosion occurred.

After a lapse of three minutes, the gas was measured under atmospheric pressure, giving a reading of 49.53. This, subtracted from 80, the amount burned, gave the contraction: $80 - 49.53 = 30.47$.

The products of the combustion, or gas remaining in the explosion burette, was transferred to the absorption tube and treated with potassium hydroxide.

Gas returned to the explosion burette and measured under atmospheric pressure, giving a reading of 41.43. This, subtracted from the previous one, 49.53, gave the amount of carbon dioxide formed by the combustion of the gas residue:

$49.53 - 41.43 = 8.1$, or, the $CO_2 = 8.1$ cubic centimeters, and CH_4 present in 18 cubic centimeters of residual gas equals 8.1 cubic centimeters, since $CH_4 = D = CO_2$, by equation 4.

For the total amount of residual gas, 89 cubic centimeters, the methane would equal, by simple proportion:

$18 : 89 :: 8.1 : X$; $X = 40.05$, or, $CH_4 = 40.05$ per cent.

The hydrogen is computed from equation 5:

$$H = \frac{2C - 4D}{3} = \frac{2(30.47) - 4(8.1)}{3} = 9.51$$

or the hydrogen present in 18 cubic centimeters of residual gas equals 9.51 cubic centimeters; hence for the total volume of residual gas, 89 cubic centimeters, we have by simple proportion

$18 : 89 :: 9.51 : Y$; $Y = 47.02$, or $H = 47.02$ per cent.

All the constituents of the sample gas have now been determined, with the exception of nitrogen, which may be found by difference as follows:

CO_2 = 0.50
C_2H_4 (illuminants) = 4.00
O = 0.50
CO = 6.00
CH_4 = 40.05
H = 47.02
Total - - - = 98.07 and

$100 - 98.07 = 1.93$, or, $N = 1.93$ per cent.

The following table of analyses serves to illustrate the wide range of work to which this apparatus is adapted:

GASES.	CO_2	O	CO	N	C_2H_4	CH_4	H
Flue Gas. .... (Bituminous coal)	9.65	8.55	0.00	81.80	0 00	0.00	0.00
Hoffman Oven Gas.	1.41	0.43	6.49	0.00	2.04	36.31	53.32
Producer Gas ..... (Bituminous coal)	2.50	0.30	27.00	55.30	0.40	2.50	12.00
Producer Gas ..... (Anthracite coal)	2.50	0.30	27.00	57.00	0.00	1.20	12 00
Water Gas........	4.00	0.50	45.00	2.00	0 00	3.50	45.00
Natural Gas	0.60	0 80	0.60	3.00	1.00	72 00	22 00
Coal Gas..........	0.30	0 40	7.60	2.80	4 30	36.50	48.10

Properties of Gases. HYDROGEN: Symbol, H; atomic mass, 1; Valence, 1; molecular mass, 2; specific gravity compared to air, 0.0695; weight of one liter, 0.089578 grams; weight of cubic foot, 0.005592.

An irrespirable, colorless, odorless, and tasteless gas, and the lightest form of matter known, being about 14.43 times lighter than air. It is slightly soluble in water, 1.9 volumes being absorbed by 100 volumes of water. Heated to about 500° Centigrade, it is combustible, combining with oxygen with evolutions of light and heat. It produces a pale, bluish flame, which becomes bright with increasing pressure. Hydrogen in burning evolves 34,462 calories per kilogram. Cooled in boiling nitrogen to −213° Centigrade, under a pressure of 160 atmospheres, hydrogen has been brought to a colorless, transparent liquid.

The reaction with oxygen is:

$$H_2 + (O_2)_{\frac{1}{2}} = H_2O$$

Preparation. Hydrogen may be prepared by the action of zinc upon an acid, as sulphuric acid:

$$\underset{\substack{\text{Hydrogen} \\ \text{Sulphate or} \\ \text{Sulphuric Acid}}}{H_2(SO_4)} + \underset{\text{Zinc}}{Zn} = \underset{\substack{\text{Zinc} \\ \text{Sulphate}}}{Zn(SO_4)} + \underset{\substack{\text{Free} \\ \text{Hydrogen}}}{H_2\uparrow}$$

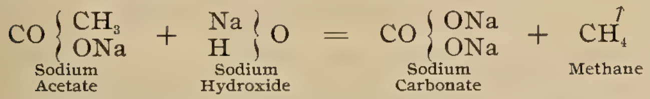
METHANE: Synonyms, marsh gas, fire damp, after damp, hydrogen carbide; formula, CH_4; molecular mass, 16; according to Meyer and Senbert, 15.97. Specific gravity compared to air, 0.5560; weight of one liter, 0.719 grams; weight of one cubic foot, 0.04488 pounds.

An irrespirable, colorless, odorless, tasteless gas, and is the next lightest gas to hydrogen. It is slightly soluble in water; combustible, emitting a pale, faintly luminous flame when burning in air. Mixed with oxygen in the proportions expressed in the reaction below, two volumes of oxygen or about ten volumes of air, forms an explosive mixture, often the cause of serious accidents in coal mines, where it collects, together with other explosive gases.

The reaction with oxygen is:

$$CH_4 + (O_2)_2 = CO_2 + (H_2O)_2$$

Preparation. Methane may be prepared by heating sodium acetate in presence of sodium hydroxide:



$$\underset{\text{Sodium Acetate}}{CO\left\{\begin{matrix}CH_3\\ ONa\end{matrix}\right.} + \underset{\text{Sodium Hydroxide}}{\left.\begin{matrix}Na\\ H\end{matrix}\right\}O} = \underset{\text{Sodium Carbonate}}{CO\left\{\begin{matrix}ONa\\ ONa\end{matrix}\right.} + \underset{\text{Methane}}{CH_4\uparrow}$$

The Elliott apparatus herein described is a modification of the older form, which is similar except that it is not provided with an explosion burette and has but a two-way cock at H′, and no outlet as at N′, making it difficult to expel any air caught in the horizontal capillary. This form is made full size, the burette being graduated to contain 100 cubic centimeters, and is quite largely used.

(Continuation in next number.)

Pneumatics

LIQUID AIR AS A NEW SOURCE OF POWER.*

DURING 1894-5 the present writer prepared two articles under the title of "Engineering Fallacies" which were published in this journal, Vol. XI, pp. 273-294, and Vol. XII, p. 125. Since that time, though several new forms of what might be termed in a general way "Perpetual Motion Schemes" have appeared, none of them has seemed of sufficient importance to warrant any special notice, but in the March number of *McClure's Magazine* there is published an article entitled "Liquid Air — a new substance that promises to do the work of coal and ice and gunpowder, at next to no cost," which is so eminently calculated to mislead the general reader and even to become the basis of financial frauds, like that of the Keely motor, that it would seem a duty to draw attention to the fundamental errors in scientific principles and in statement of facts which this article contains.

This *McClure* article may be fairly considered as made up of two prominent elements or parts, one of which is the statement of certain things as facts which, as I shall presently show, cannot possibly exist and are inconsistent with other facts stated in the same article and known from other sources to exist as so stated; while the other main element consists of rather vague statements concerning general principles which, though in a general sense true, yet as here used are calculated to cover up or befog the too obvious inconsistencies of the statements of facts, with the established principles of science.

As an example of the first element, we find on page 400 as follows: "I have actually made about ten gallons of liquid air in my liquifier by the use of three gallons in my engine." This I shall presently show is simply impossible and inconsistent with data given elsewhere in this article and known to be substantially correct.

A sample of the other element is found on page 399 in the following: "That is perpetual motion you object. 'No,' says Mr. Tripler, sharply; 'no perpetual motion about it. The heat of the atmosphere is boiling the liquid air in my engine and producing power exactly as the heat of coal boils water and drives off steam. I simply use another form of heat. I get my power from the heat of the sun; so does every other producer of power."

This, while true as a general statement of what might be done on an impractical scale, is not correct as here used to imply that in his experiments Mr. Tripler actually derives or can derive any adequate amount of energy from the heat of the atmosphere, or in that sense directly from the sun. This I shall show later, but will first take up the statement that three gallons of liquid air have supplied or can supply the power to liquify ten gallons.

On pages 402 and 403 of the *McClure* article we are told that Mr. Tripler uses to make his liquid air a steam engine of 50 horse-power, and that with this he can make liquid air at the rate of 50 gallons a day. This I know from other sources is substantially correct, and means that *each horse-power in a day (say 10 hours) makes one gallon of liquid air.* In other words, one gallon for 10 horse-power hours.

It is again stated in this article, on page 405, that a cubic foot of liquid air contains 800 cubic feet of air at ordinary atmospheric temperature and pressure, or in other words, any volume of liquid air, if adequately heated, will expand 800 times in reaching atmospheric temperature and pressure. This also is substantially correct. We may remark in passing, that this is nothing wonderful, for water, when expanded into steam at atmospheric pressure, increases about 1700 times in volume, or more than twice as much as liquid air. If we apply to the above data the well known and universally accepted formula* for the maximum work done by air when expanded at constant temperature, we find that a pound of liquid air in expanding 800 times would develop about 190,000 foot-pounds of work. As a gallon of liquid air weighs about eight pounds, this would give eight times as many foot-pounds, or 1,520,000. If this work were accomplished in an hour, it would represent almost exactly ¾ of a horse-power, because one horse-power means 1,980,000 foot-pounds of work per hour, and 1,520,000 is only a trifle over three-fourths of this. From the above, it follows as a matter of *absolute certainty* that the maximum power which liquid air could develop in an *ideally perfect engine* without any loss from friction or other cause, would be *three-fourths of a horse-power for an hour for each gallon of liquid air expended.*

We have seen, however, that with his 50 horse-power plant, which on account of its size should operate with considerable efficiency, Mr. Tripler *makes only one gallon* of liquid air with *10 horse-power hours.* In other words, he requires to make a gallon of liquid air *12 times as much power* as a gallon of liquid air could *possibly develop in an ideally perfect engine.*

In face of this, how supremely absurd is the statement that with a little engine such as the pictures and descriptions in the *McClure* article show, lacking all conditions for efficient working, Mr. Tripler can make 10 gallons of liquid air by the use of three.

Turning next to the statement about using the heat of the atmosphere to develop mechanical energy or work, let us put this to the test of a quantitative example.

Assume the temperature of Mr. Tripler's laboratory to be 70° F., and that he has an abundant supply of water at 50° F These will be, of necessity, the limits of work he can get out of the atmosphere, because any lower temperature is only secured by doing work and so expanding energy which will be at least equal to the power obtainable from the use of such lower temperature. All the work that can be obtained *for nothing* is that which nature will freely give in the warm air and cool water, supposing both to be supplied freely without charge.

The 20° F. which we may assume as being possibly taken out of the air by the cool water, will represent the maximum gift of nature in this shape of "power costing nothing." Now 42 British thermal units, or pounds of water changed 1° F. per minute, will represent one horse-power, and as the specific heat of air is about one-quarter that of water, we would need four times as many pounds of air to produce the same effect. This would call for 168

(Continued on page 99.)

---

*Prof. Henry Morton, Ph. D., LL. D., Sc. D., in *Stevens' Indicator.*

*$W = p_2 v_2 \text{ hyp log } \frac{v_2}{v_1}$

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity and Transmission of Power.

Official Organ of the Pacific Coast Electric Transmission Association.

Subscription invariably payable in advance. Terms—Domestic, One Dollar per Year; Foreign, Two Dollars per Year. The trade supplied by the San Francisco News Company. Advertising rates furnished on application.

GEO. P. LOW, : : : Editor and Proprietor

PUBLICATION OFFICE:
320 CALIFORNIA STREET,
ROOM 14.

Address all communications to
Editorial rooms, 315 CHERRY ST.
Telephone, "Steiner 627."

SAN FRANCISCO, CAL.

ENTERED AS SECOND-CLASS MATTER AT THE SAN FRANCISCO POSTOFFICE

VOLUME VII JUNE, 1899 NUMBER 6

EDITORIAL.

THE WRATH OF THE PEOPLE.

Whether deserved or otherwise, it is undoubtedly true that, perhaps with the single exception of street railway companies, gas companies constitute the class that is more reviled by the public than any other line of corporations catering public commodities. Electric lighting interests have, as a rule, been far less under the ban of common censure than have their gas cousins, probably because of the true competition which electricity has afforded, but when the quondam gas company and the likewise quondam electric company of a community bury their animosities, unite and deport themselves with airs of monopolistic arrogance —buy legislative bodies, prevent the granting of franchises to competing companies, and maintain extortionate rates — then the public at last ceases to forbear longer and the stock market records indelibly the rash consequences of their misdoings. For the companies to rebuff these criticisms with words or actions bespeaking a Vanderbiltian condemnation of the public is at least impolitic; to dismiss them as idle riff-raff is puerile; to placate them with ne'er to be fulfilled promises hastens the day of reckoning, and to rely implicitly on the power of money is a species of self-incrimination not to be always misunderstood.

Patient and long-suffering though the public may be, it is fatal to not remember that it has its last straw of endurance and that when it has been reached the distress of the over-burdened community will be reflected immeasurably, though indirectly, on the earning and market values of the corporations. Among these penalties are, briefly, the perennial agitations of socialistic natures; the organization of competitive companies, some being *bona fide*, but many being "sell outs," and the ever growing cry for the municipal ownership of quasi-public utilities, all of which owe their motherhood to conditions first voiced in the clamor of denunciation heaped upon unpopular corporations.

Merchants attain success best through honesty and fair dealing which induce the prime-essential popularity requisite to the upbuilding of a fortune. Are quasi-public corporations inherently so constituted that they can not appreciate these truths? We judge not, although the list of evident *incorrigibles* is of appalling length.

DETERMINING WATER WHEEL EFFICIENCIES.

Away back in 1786, James Rumsey, who was a friend of Robert Fulton long before the latter had made his name immortal through the invention of the steamboat, and from whom, indeed, Fulton is said to have gotten the idea of steam navigation, propelled a quaint boat on the Potomac River through the instrumentality of a powerful steam pump which forced water through a battery of tubes placed in the stern of the vessel. The streams of water, striking against the surface of the river, shoved the boat along against the current of the stream at a speed of five miles an hour.

Here in the closing and, consequently, most enlightened year of the nineteenth century, hydraulic engineers the world over place the buckets of a tangential wheel directly in a jet of water close to its orifice and then consider the spouting velocity of the jet as unaffected by the presence or action of the buckets. If this reasoning were true, Rumsey's boat would have been incapable of self-propulsion. The two conditions, though reversed, are parallel; for while in each case the energy of the jets is converted into motion, work is performed, so to speak, at the sacrifice of velocity.

The question which naturally arises is: Why make the theoretical spouting velocity of the jet the basis of determination of water wheel efficiency when its actual spouting velocity can by no means equal the theoretical spouting velocity?

It would seem that an investigation of this subject would at least result in the re-determination of some of the water wheel efficiencies that have become accepted in hydraulic engineering practices.

Passing Comment

An Editorial Review of Current Events and Comtemporury Publications.

QUALIFICATIONS OF AN ENGINEER'S ASSAILANTS.

Even the lay press has periods of sanity in discussing matters electrical — at least one San Francisco daily, *The Examiner*, has given evidence of realizing that this is a day of specialists, and that the opinion of an engineer who has attained eminence in his profession is not to be blown aside lightly as by supervisorial verbiage or the gust of wind from a flying beer cork, for thus does *The Examiner* discuss the reception given by the honorable Board of Supervisors of the City and County of San Francisco to the report of A. M. Hunt, on the cost of a plant for lighting the streets and municipal buildings of the city:

The friends of the gas combine are badly shaken up by Engineer Hunt's estimate of cost and operation of a municipal plant capable of lighting the streets and public buildings. The one answer that they have been able to suggest is, "The figures are wrong."

That able expert, Supervisor Collins, who gets his electrical experience as the secretary of a hay and grain establishment, says, "I will show that Phelan's (Hunt's) figures are far from correct."

Supervisor Kalben, who gets his knowledge of the electrical business by his connection with the California Bottling Company, says, "I know it can't be had for the sum Hunt says."

Supervisor Attridge, who has qualified himself by being a shoemaker to pass on Mr. Hunt's report, says, "We (Collins and myself) are preparing a report which will deal fully with the question," and some remarkable estimates may be expected.

Meanwhile, the Mayor stands by Engineer Hunt's report, and apparently with good reason. It is true that Mr. Hunt is neither a bottler nor a shoemaker, and has not had the advantages that come from running a hay and grain business. But he is a graduate of the United States Naval Academy, a specialist in electricity, the electrical expert of the Midwinter Fair, the consulting or superintending engineer for most of the big electrical works of the State, and has high standing in his profession. When he says that the plant can be set up for $459,005, and can be operated for $170,838, including labor, materials, depreciation and repairs, there is good ground for supposing that his figures are correct.

* * *

AN ENGLISH METHOD OF DRYING TRANSFORMERS.

Mr. Hamilton Kilgour, in a paper read before the Northern Society of Electrical Engineers,* states that transformers of the 650-watt size, or thereabouts, used for arc lighting and placed in the bases of lamp posts, and which have given trouble from dampness, have been successfully treated by passing short lead covered cables through the glands and connecting them to the primary and secondary terminals in the manner to be described. These glands and all openings into the transformer case, except the door to the fuses, are sealed up; the transformers are then taken in batches into a hot dry room where the primaries are connected in parallel to a 100-volt circuit, and the secondaries in series to a low resistance, by which the secondary current can be varied from about eight to fifteen amperes as desired. Pots of calcium chloride are inserted through the fuse doors, which are then sealed up. The transformers are run in this way for about a week, the calcium chloride being changed frequently at first, and the fuse door resealed after each charge. Toward the end of the week very little water is found to remain in the transformers, and at the end of this preliminary run each transformer is given a new quantity of calcium chloride and is finally sealed up. They are then run individually for some hours, or perhaps a day or two, with their primaries connected to a 2000-volt circuit and their secondaries to arc lamps; the primary is also flashed to the case with 2000 volts. Larger transformers are dried in a somewhat similar way, except that they are usually dealt with individually and have their secondaries connected through resistances to a low pressure circuit and their primaries to lamp loads.

In marked contrast to this method is the one which is almost universally used in this country, namely, simple baking in the dry kiln until the transformer has been brought up to an insulation resistance of at least one megohm for each 1000 volts to be applied under working conditions.

Transmission

CALCULATING TRANSMISSION CONDUCTORS.*

BY PROF. GEORGE FORBES, F. R. S., M. I. C. E.

Up to the present date financial men have not realized the value of long distance transmission. Engineers, too, have been so much engaged with electric lighting and traction that few have devoted much time to its study. The last nine years of my life have been devoted almost entirely to electric transmission and the last four years to very distant transmission. At present there exist no printed tables for facilitating calculations, such as civil engineers possess in other branches of the profession. In the case of electric transmission, every engineer must prepare his own sets of tables and curves to work from. I have been compelled to work these out for myself in various units, hence you will believe that I possess a mass of tables and curves, and these might be worth publishing if the time had arrived, which is not perhaps yet. During these years, however, my methods have become so simplified that I venture to bring to your notice one curve in relation to the one special question of efficiency and cost of transmission lines. It is so simple in its present form through a gradual evolution that I cannot help thinking that it may be of use to others.

In transmission schemes the cost of copper becomes so all-important, when dealing with long distances, that it helps more than I can tell you to have simple means for estimating even roughly the cost and efficiency under various conditions. I feel some diffidence in laying before you these methods, because there is nothing new in the results, and all the results can be obtained by the ordinary methods. They have, however, been invaluable to myself. These methods are particularly useful for getting out preliminary estimates quickly.

Here let me say that in all preliminary work on the cost of long conductor lines I never take notice of the resistance of the conductor, nor of the value of the current. I deal only with the current density and loss of volts. It is the same thing under a different name. But it is what you want.

Again, I never use for calculations for my own use the efficiency of the conductor system. It is far more convenient to use the inefficiency or the reciprocal of the efficiency, which is also the horse-power put into the generating end of the line to deliver one horse-power at the other end.

I suppose everyone present is aware of the fact that if you had a case where the power cost absolutely nothing, you would use the least copper and have the cheapest arrangement, with an inefficiency of two; *i. e.*, an efficiency of 50 per cent., or two horse-power generated for each horse-power delivered. If you make the current density either greater or less than what is required to produce this inefficiency, then you have to use more copper to deliver the same quantity of power. This is a point which in a general way is appreciated by the business man who is not an electrician, as has been already stated.

Figure 1 shows this very well, and a study of it is interesting. We see that the copper required to transmit one horse-power 100 miles at an initial pressure of 10,000 volts, with continuous current, falls with the increase of density until the efficiency is 50 per cent., and then rises. This figure shows the weight of copper required per horse-power delivered at a distance of 100 miles at 10,000 volts. It is drawn for the simplest case of continuous current, to which corrections only for temperature and sag have to be made. It is equally applicable to a single-phase or two-phase alternating transmission to 100 miles at 10,000 effective volts, or at 5000 effective volts from any wire to the middle of the electric system, or to three-phase transmission to 100 miles at 5000 effective

---

*Reprinted in *The Electrician*, Vol. XLII, No. 6, June 2, 1899.

*Excerpt from a paper read before the Society of Arts, London.

volts from any wire to the middle of the electric system. But with alternating current corrections must be made for self-induction and capacity. The same remarks apply to the meaning of the voltage of the line in all the curves and tables referred to. They are worked out for continuous current, and for any other system the engineer must add the usual corrections.

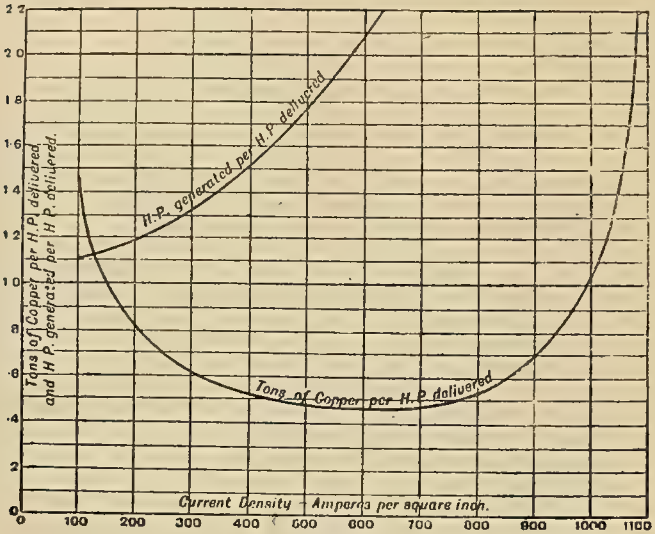


FIGURE 1.

Another curve may be drawn showing the inefficiency at each current density. This curve constantly rises; *i. e.*, the greater the current density, the greater is the inefficiency.

Now from these two curves we can deduce a third curve, which is the one I find which gives one in a few minutes all the main facts one wants for any horse-power to be delivered to any distance at any initial volts.

The curve gives the tons of copper per horse-power delivered at 100 miles with 10,000 volts continuous current, in terms of the horse-power generated per horse-power delivered.

Measuring along a horizontal line you get the inefficiency, *i. e.*, the horse-power generated for each horse-power delivered; and measuring vertically, you get the corresponding tons of copper required for each horse-power delivered at a distance of 100 miles. The curve is also marked with figures to show the current density in amperes per square inch section of copper.

I never travel a day without this curve in my pocket. The curve is correct for 100 miles and 10,000 volts or for any other case where volts equal 100 times the mile. The curve shows you, for example, that for an inefficiency of 1½ you require a current density of 387 amperes per square inch, and .55 ton of copper. And thus current density and weight of copper per horse-power is the same whether you use 10,000 volts at 100 miles or 100 volts at one mile.

For any other volts and distances in miles, V and M, you divide the volts by the miles and get $\frac{V}{M}$; then $\frac{V}{100M} = D$, the multiplier for the current density, and $\left(\frac{V}{100M}\right)^2 = T$, the divisor, for the tons of copper per horse-power.

As an example, 15,000 volts and 300 miles. Here

$$D = \frac{15{,}000}{100 \times 300} = ½.$$

Hence, for an inefficiency as above of 1½, the current density will be ½ × 387 = 198. The tons of copper per horse-power will be

$$\frac{.55}{(½)^2} = 2.20 \text{ tons.}$$

Now let me show you another use of the curve. Suppose we capitalize the cost of running the generating station, and add to it the cost of the generating works, and divide by the horse-power, we have then the capitalized value of one horse-power generated; I will call it for short the value of one horse-power generated. We also know the cost of one ton of copper. Divide the value of the horse-power by the value of the ton of copper, and draw a line across the axes so that it cuts the axes in that ratio. Draw a line parallel to this and touching the curve. This gives you, according to Lord Kelvin's law (as modified by Ayrton and Perry), the point of maximum economy, giving directly the inefficiency, the tons of copper per horse-power, and the current density. Thus on the curve two examples are shown, one where the value of one horse-power is four times that of a ton of copper. In this case the greatest economy is got by an inefficiency of 1.18, a current density of 180 amperes per square inch, and 0.91 tons of copper per horse-power delivered at 100 miles distance, the initial pressure being 10,000 volts.

Another example is shown on the curve where the horse-power is one-fifth of the cost of a ton of copper.

The resulting values are seen directly to be: Inefficiency = 1.58; current density = 420; copper = 0.51 tons. To do this for other values of T $\left[T = \left(\frac{100M}{V}\right)^2\right]$ you must divide the value of the horse-power by T. Measure this distance vertically by the unit on the vertical scale, or by fractions of these units, and measure the cost of a ton of copper horizontally by the unit on the horizontal scale or by the same fraction as before of that unit. Join the two points by a line and draw a parallel line touching the curve at the point of maximum economy.

You will see how valuable such a curve must be for obtaining the very information that an engineer requires in his first examination of any project. But we can do more than this. Divide the tons of copper per horse-power by 18 times the distance in miles, and you get the sectional area in square inches of the conductors (go and return) per horse-power. Multiply this by the total horse-power to be delivered and you get the size of your conductors. Remember that this is all worked out for *continuous current*, and must be corrected for other systems as well as for temperature and sag.

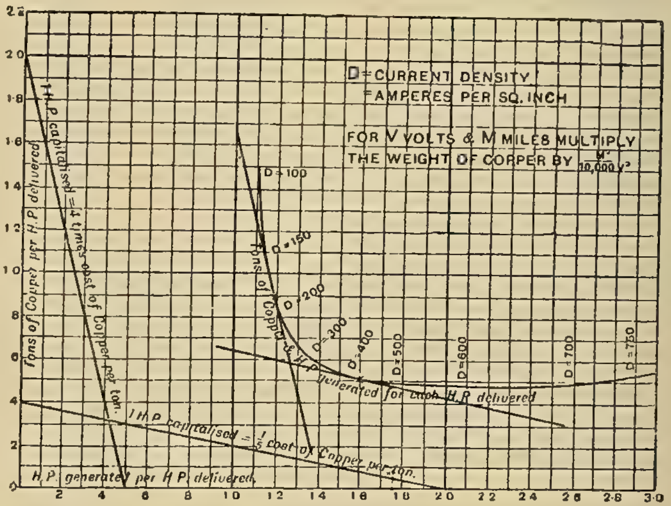


FIGURE 2.

Some people prefer to work by tables instead of by curves, so I will put down the readings of the curve which we have just been discussing. For ordinary work the following is sufficient:

Inefficiency	Tons Copper per HP.	Current Density	Inefficiency	Tons Copper per HP.	Current Density
1.20	.86	190	1.70	.49	475
1.30	.66	266	1.80	.48	510
1.40	.58	330	1.90	.472	545
1.50	.55	387	2.00	.470	574
1.60	.51	432			

In most practical cases, however, the economical inefficiency for long distance transmission lies between 1.20 and 1.50. The following table gives closer values over this range:

Inefficiency	Tons	Density	Inefficiency	Tons	Densisy
1.20	0.86	190	1.36	0.60	306
1.22	0.80	207	1.38	0.59	319
1.24	0 76	221	1.40	0.58	330
1.26	0.72	236	1.42	0.57	342
1.28	0.69	250	1.44	0.56	354
1.30	0.66	266	1.46	0.55	365
1.32	0.64	279	1.48	0.54	376
1.34	0.62	292	1.50	0.53	387

From either of these tables, having given the inefficiency, to get the density for any volts and distance, multiply the above value by $\frac{V}{100M}$, and to get the tons of copper divide the above value by $\left(\frac{V}{100M}\right)^2$

This little table enables us then, with a very simple piece of arithmetic, to get the result for any case that may arise, sufficiently close. But in actual practice I find it far more useful to have the table extended in such a way that an approximate result may be arrived at without any calculation.

Three tables are here given. The first gives a reference letter for any volts and distance. In the second and third tables the results we want are found under that reference letter. The second table gives the tons of copper per horse-power delivered, and the third gives the current density for any inefficiency that we may select.

TABLE I.—DISTANCE OF VOLTS.

Virtual Volts between Wires.						
One or two-phase........	5000	10,000	15,000	20,000	25,000	30,000
Three-phase..............	4325	8,650	12,975	17,300	21,625	25,950
Distance in Miles.						
A...........................	12.5	25	37.5	50	65.5	75
B...........................	25	50	75	100	125	150
C...........................	37.5	75	112.5	150	187.5	225
D...........................	50	100	150	200	250	300
E...........................	62.5	125	187.5	250	312	375
F...........................	75	150	225	300	375	450
G...........................	87.5	175	262.5	350	437.5	525
H...........................	100	200	300	400	500	600
K...........................	150	300	450	600	750	900

TABLE II.—TONS OF COPPER PER HORSE-POWER DELIVERED.

Inefficiency	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
A.......	.0537	.0412	.0362	.0344	.0319	.0306	.0300	.0295	.0294
B	.2150	.1650	.1450	.1375	.1275	.1225	.1200	.1180	.1175
C.......	.4837	.3725	.3262	.3094	.2869	.2756	.2700	.2655	.2644
D.......	.8600	.6600	.5800	.5500	.5100	.4900	.4800	.4720	.4700
E.......	1.344	1.031	.9062	.8594	.7969	.7656	.7500	.7375	.7344
F.......	1.935	1.499	1.305	1.237	1.148	1.102	1.080	1.062	1.058
G.......	2.634	2.020	1.776	1.684	1.562	1.504	1.470	1.446	1.439
H.......	3.440	2.640	2.320	2.200	2.040	1.960	1.920	1.888	1.880
K.......	7.740	5.940	5.220	4.950	4.590	4.410	4.320	4.248	4.230

TABLE III.—CURRENT DENSITY.

Amperes per square inch.

Inefficiency	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
A.......	760	904	1,320	1,448	1,728	1,900	2,040	2,180	2,296
B	380	452	660	724	864	950	1,020	1,090	1,148
C.......	253	301	440	515	576	633	680	727	765
D.......	190	226	330	387	432	475	510	515	574
E.......	152	181	264	310	346	380	408	437	459
F	127	151	220	258	288	317	340	363	383
G.......	108	129	188	221	246	271	292	311	327
H.......	95	113	165	193	216	237	255	272	287
K.......	63	75	110	129	144	158	170	182	191

RULES FOR USING THE TABLES.

Rule 1.—*To find the reference letter.* In Table I, in the column referring to the volts generated, find the approximate distance of transmission in miles. The capital letter at the beginning of the line in which this is found is the reference letter.

Rule 2.—*To find the tons of copper per horse-power delivered.* Look along the row in Table II referring to the reference number, and tons of copper are there given for each inefficiency. The inefficiency being the horse-power generated to deliver the horse-power at the distant point.

Rule 3.—*To find the current density.* Table III gives this in amperes per square inch in the row corresponding to the reference number, and in the column corresponding to the inefficiency chosen.

Rule 4.—*To find the economical conditions of working* (Kelvin's law). Divide the capitalized value of one horse-power by the cost of one ton of copper. Divide this by 10 and call it q. In Table II look along the row corresponding to the reference letter until the difference between successive numbers is approximately q. The number at the head of that column is the economical inefficiency, the tons are also then given, and the current density is obtained directly in Table III.

Rule 5.—*To find the total section (go and return) of all the transmission conductors.* Multiply the tons per horse-power by the total horse-power, and divide by 18 times the distance in miles. This is the result in square inches. Dividing this by the number of conductors gives the sectional area of each.

I trust that all here present who are not engineers realize now that the cost of transmission of electric power to a distance is a pure question of balancing expenditure and profits. By the methods now described, or by the ordinary methods, there can be no question as to the cost of the work. The only point, in fact, affecting the cost which has been left to the choice of the engineer is the electric pressure to be used, and every engineer in reporting on a scheme generally gives his reasons for selecting the pressure. In old days the highest pressure for which we could get a guarantee from contractors was used. But the expense of insulation was increased so much with increase of pressure that now, as at Rheinfelden, we work to that pressure which is the most economical. Manufacturers will now guarantee any pressure if you will pay for it.

Having now determined with sufficient accuracy the cost of the works and their maintenance, annual expenses and interest on mortgage, the next thing is to see (or perhaps this ought to be the first matter attended to) what return can be obtained for the power delivered to a distance. It is then for the purely financial men to say whether the profits to be derived are worth the venture.

LIQUID AIR AS A NEW SOURCE OF POWER.

(Continued from page 95.)

pounds of air changed 1° F. If, however, the air is changed 10° F. in place of 1° F., we need but $\frac{1}{20}$ or 8.4 pounds of air parting with 20° F. each minute, to give us one horse-power at 70° F. For "round numbers" let us say 8 pounds. Now a pound of air has a volume of about 13.3 cubic feet. Call this also "for round numbers" 13 cubic feet; then 8 pounds of air would be about 104 cubic feet, and this volume of air would have to part with its 20° F. heat each minute to the apparatus, in order to develop *one* horse-power. For a 50 horse-power engine 50 times as much air would be required, or 5200 cubic feet each minute; this would be the contents of a room 26×20 feet on the floor and 10 ten feet high which would have to be drawn through the apparatus each minute in such a way as to completely yield its 20° F. between 70° F. and 50° F. What sort of a boiler or heat-absorbing apparatus can we imagine which would absorb from air, at 70° F., 20° F. of its temperature while the said air was passing through it at the rate of 5200 cubic feet a minute? It would surely need to be "as big as a house," to use a familiar phrase.

This also, be it remembered, makes no allowance for loss by friction, eddy currents and the like, which would be enormous, nor for the power to put this air in motion.

Obviously such a machine would be simply huge in size, and indeed the friction involved in it would probably use up a large part of the power it could develop.

Suppose, however, that it could be built and operated in place of Mr. Tripler's 50 horse-power steam plant. Its entire output would be 50 gallons of liquid air a day, and this, as we have seen, could only develop in an ideally perfect engine ¾ horse-power for an hour for each gallon, or 3¾ horse-power for a day of ten hours! This does not look as if heat obtained from the atmosphere and operating an engine by aid of liquid air was likely to become a dangerous rival to the coal mine.

On page 402 of the *McClure* article it is stated that Mr. Tripler makes his liquid air at a cost of 20 cents a gallon. We have shown above that the maximum power obtainable from this liquid air, by heating it to ordinary atmospheric temperature, is ¾ of a horse-power-hour. This, at 20 cents, would be vastly more expensive than power derived from an ordinary steam engine, whose cost ranges from less than one cent per horse-power-hour under the best conditions, to three or four cents, where a profit is included, or the conditions are less favorable.

The really difficult thing to explain in connection with this *McClure* article on Mr. Tripler and his liquified air, is how those concerned in its publication (being, as I do not doubt, honest men) can be deceived, or have so deceived themselves, as to make and repeat such obviously impossible statements.

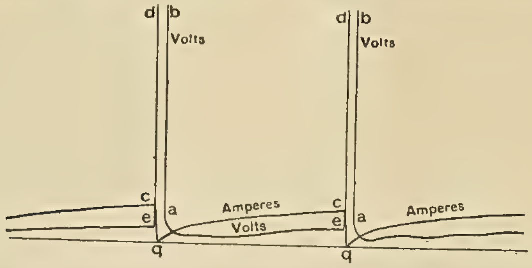
I could give from my own personal experience many like examples, but have said enough for the present to make it evident that what is claimed in this *McClure* article for liquid air as a new source of "power which costs nothing," is not founded on fact, but is probably the result of some oversight in observation or calculation not inconsistent with honesty of intention.

Physics

THE WEHNELT ELECTROLYTIC INTERRUPTER.*

BY A. BLONDEL.

THE action of the curious Wehnelt interrupter, recently presented to the Académie by M. D'Arsonval, has not yet been fully explained. It has been well established by experience that the essential condition for its oscillatory working is that the circuit be inductive. Without self-induction, the interrupter immediately stops working, the anode gets red, and a very weak current passes continuously. The self-induction of the coil, or a supplementary inductive coil suffices to produce the phenomenon, and the frequency of the latter may be varied from one to several thousands per second by varying the inductance. One may, therefore, think, with the numerous writers who have already expressed their opinion, that it is a question of resonance between the self-induction and the capacity of the condenser formed by the polarized anode. This capacity may, for instance, reach one or two micro-farads with a platinum wire 10 millimeters long and 0.5 millimeters diameter.



But this interpretation, based on the hypothesis of sinusoidal variations for alternating currents, would not explain how the increase of electromotive force, working on a circuit of invariable composition, can increase the frequency. Neither does it seem to be confirmed by a direct study of the current curve. For example, the curve in the figure, copied from curves of current and electromotive force taken by means of my 5000 period oscillograph, by MM. Duris, Farmer, and Tchernosbitoff under my direction, indicates a single oscillation. The experiment was made at 40 periods, with a self-induction of from 0.2 to 0.3 henry in series with the interrupter. The latter had a wire similar to that already referred to. The pressure of the battery was 33 volts, the current five to six amperes; the pressure at the terminals of the cell increased to 75 volts. The figure shows that the current is first established as in all inductive circuits; the electrolysis continues to increase until the production of the gaseous envelope around the anode, then directly it is completed there is a sudden interruption of the current, and, at the same time, an enormous increase in voltage, projecting the spot outside the field of vision. Then both the current and the pressure resume their initial values and the action begins again. The precautions which we have taken to give to the circuit a slower proper period than that of the oscillograph, permits us to think that these indications may be relied upon.

Under these conditions the phenomenon of interruption only occasions one single aperiodic impulse. The energy $\frac{1}{2}LI^2$ accumulated in the self-induction, and liberated by the interruption of the current, causes the condenser formed by the polarized anode in the electrolyte to be charged at high potential. This condenser destroys itself by discharging in an arc which is formed between the platinum and the electrolyte, and drives away the dissociated oxygen. The anode is therefore immediately freed from gas, and is again in contact with the liquid which condenses the vapor, if any remains, and permits the current to flow again immediately. This action may be approximately compared with that of a hydraulic ram or a pulsometer. This explanation allows one to understand the necessity of a certain proportion between the self-induction and the anode without it being necessary to liken the phenomenon to a true resonance. One understands also why the employment of a high voltage, which increases the rapidity of the electrolysis, can increase the frequency. Finally, the form of the volts curve suffices to explain the large increase of the mean pressure at the terminals of the cell, pointed out by MM. Wehnelt and Pellat. The oscillograph used did not lend itself to an examination of the action at high frequencies, but one may fairly believe that the phenomenon preserves the same character whatever the frequency. The explanation which I have proposed may, therefore, be general.

---

*From the *Comptes Rendus*, April 4, 1899.

The forthcoming Mechanical and Electrical Vest-Pocket Manual compiled by Sidney Sprout, the well-known electrical engineer, will contain 204 pages of tables and data treating on electricity, steam, power, street railway, and many other subjects, and will be of almost indispensable value to engineers and others. The book will be 2¾ by 5½ inches, handsomely bound in leather, with gilt edges and round corners, and will sell for $1.00 per copy, postpaid. For further information, address Sprout & Stevens, 519 Emma Spreckels Building, San Francisco, Cal.

TABLE OF CONTENTS.

Illustrated articles are designated by an asterisk (*); Editorials by a dagger (†); Passing Comment by a double dagger (‡), and Industrial by a section mark (§).

Gas

Industrial Gas—III, by Frank H. Bates 92

Hydraulics

†Determining Water Wheel Efficiencies 96

Miscellany

‡An English Method of Drying Transformers 97
‡Qualifications of an Engineer's Assailants 96
†The Wrath of the People 96

Personal

.... 92

Physics

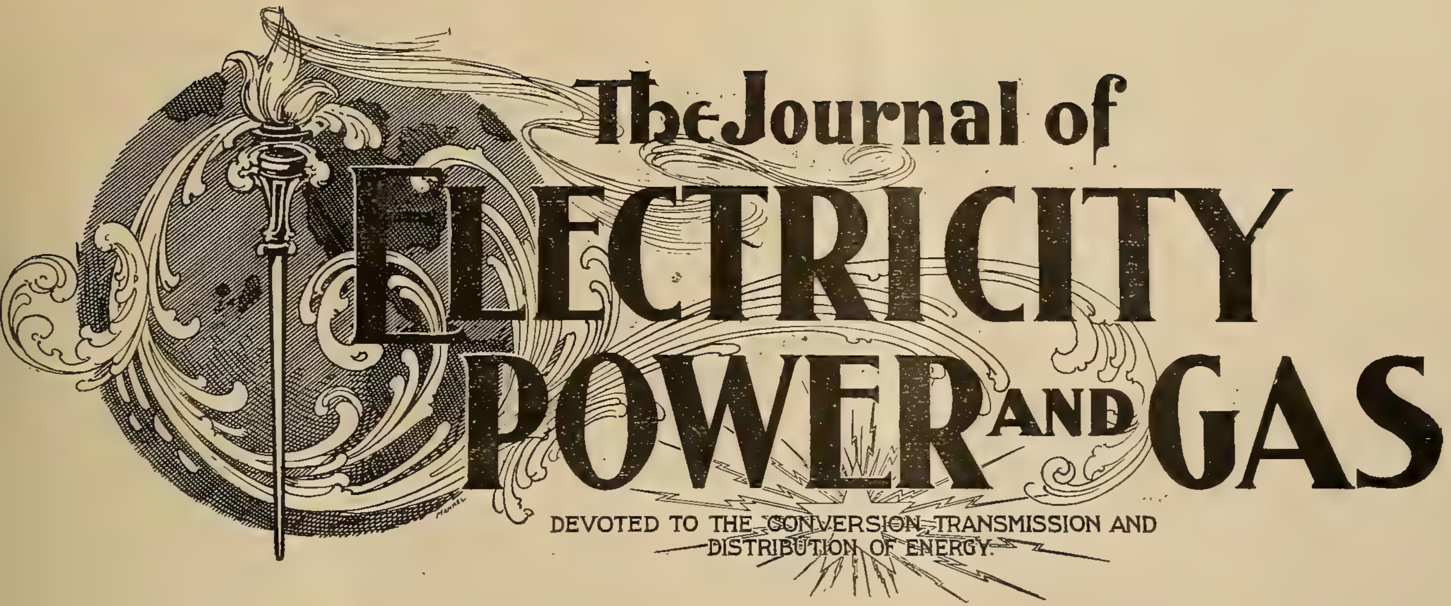
*The Wehnelt Electrolytic Interrupter, by A. Blondel 100

Pneumatics

Liquid Air as a New Source of Power 95

Transmission

*Calculating Transmission Conductors, by Prof. George Forbes, F. R. S., M. I. C. E. 97
*The Kootenay-Rossland Power Transmission, by Geo. P. Low, —Concluded 85



The Journal of ELECTRICITY POWER AND GAS

DEVOTED TO THE CONVERSION, TRANSMISSION AND
DISTRIBUTION OF ENERGY.

VOLUME VIII

JULY-DECEMBER

1899

SAN FRANCISCO, CAL.

Conducted by

GEO. P. LOW

THE JOURNAL OF
ELECTRICITY, POWER AND GAS.

VOLUME VIII. SAN FRANCISCO, JULY, 1899. NUMBER 1.

Electrically-Driven Centrifugal Pumps.[*]

BY LEWIS A. HICKS, C. E.

THE drought of the past two years in California has been productive of great expansion in the manufacture of pumps suitable for irrigation purposes, and the contemporaneous development of numerous projects for the electrical transmission of water power, at such intensities that distance comes to be of decreasing importance, is favorable to the continued utilization of pumping as a means of supplying water for irrigated land, insuring crops in dry years, and so maintaining land values and load factors.

TESTING AN ELECTRICALLY-DRIVEN CENTRIFUGAL PUMP.

The Kern County Land Co., through whose courtesy the writer is permitted to present the experiments hereafter described, has engaged in the pumping business on a scale of considerable magnitude, involving the use of some 600 or 700 horsepower, inclusive of the plants now in use, in course of construction, and in contemplation. The plants as first installed consisted of four wells, of 13-inch perforated casing to a depth of 70 to 80 feet, connected by common suction pipes to a No. 12 centrifugal pump set on the floor of a pit 8 to 12 feet deep, the average depth to the standing level of well water. The pumps were belted to 30-horsepower induction motors, actuated by three-phase current purchased from the Power Development Company, and when in operation draw the water down in the wells to a depth of 20 feet, making a total lift of 28 to 34 feet, and deliver a flow of three to four cubic feet per second. Several stations a mile or more apart are operated by one attendant, not a mechanic, and the heavy belts and hot bearings soon proved a source of annoyance and expense, which led to the consideration of coupling the pump direct to the motor. During wet years, or periods of heavy irrigation in the vicinity of pumping stations, the water level rises to a point that would submerge the band wheel of the pump, while in periods of extreme drought it may fall below suction depth. The natural relief from these difficulties was to resort to the use of vertical shaft pumps, direct-coupled to vertical shaft motors, a plan which would make it possible to set the pumps as deep as might seem desirable, regardless of the height of the water line, while retaining the motor on the surface out of danger.

Such motors were not on the market at that time, but it was felt that the advantages gained by such an assembly would justify the development of suitable motors if it proved possible to construct a pump which would give a satisfactory efficiency under the proposed conditions; *viz.:* inlet and outlet areas ten inches in diameter and a capacity of five cubic feet per second when operating at 900 revolutions per minute against a total lift of 30 feet.

---

[*] A paper read before the Third Annual Convention of the Pacific Coast Electric Transmission Association, San Francisco, June 20-21, 1899.

As ordinarily constructed, the relation between the peripheral runner speed and the height of lift is expressed by the formula

$$d \times \pi \times R. P. M. = 60 \times 10\sqrt{h}$$

where d = the diameter of the runner and h the height of the lift, both in feet. In any given pump the expression d × π is, of course, a constant, and the speed varies with the square root of the head. Applying this formula to the case under consideration to obtain a suitable runner diameter for a constant speed of 900 revolutions per minute, we find that the resulting value of d is but little in excess of the specified area of the suction inlet and there would consequently be no room for the working vanes. Increasing the diameter of the runner to allow for the vanes necessarily increases the peripheral speed beyond ordinary limits. The question was submitted to several of the leading manufacturers of centrifugal pumps on the Coast without eliciting any marked desire on their part to undertake the problem otherwise than as an experiment at our expense, without any guarantee as to results, it being the commonly expressed idea that the high peripheral speed of the impeller would decrease the efficiency of the pump below the limit set.

THE INDUCTION MOTOR WAS MOUNTED VERTICALLY.

Byron Jackson, a well-known pump manufacturer of San Francisco, was the only person who squarely accepted the specification that the manufacturer must guarantee a pump efficiency of 50 per cent., the lift to be calculated from the sum of the static and frictional resistances as indicated by gages on suction and discharge pipes, failing in which the pumps were to remain the property of the contractor.

For the purpose of this experiment it was decided to use a standard General Electric 30-horsepower, 550-volt induction motor of the compensator type, turned over on its side, supported on the stud bolts which fasten the side shields to the field frame, and coupled direct to the pump shaft with ordinary flange couplings. As the correctness of the results might be called in question by the contractor in the event of our refusing to accept the pump, it was thought best to determine the characteristic curves of the motor to be used in testing the pump by means of absorption dynamometer tests. The friction brake was of the usual Prony type, eight inches in width, with a lever arm 3½ feet long, from the end of which the resultant was delivered by a reducing lever with a three-to-one reduction to a spring balance graduated to read to single ounces, giving a brake arm in effect 10½ feet in length, and modifying the ordinary brake formula to the following:

$$HP. = .002 \times R. P. M. \times \text{scale reading}.$$

The brake blocks and lever arm were balanced in place on knife edges, and were used on a 13-inch cast iron pulley, the crown of which had been turned off flat the width of the brake blocks. The pulley was so arranged that it could be cooled from the inside with water, and it was found that the motor could be held at any desired output for a considerable interval without undue heating. The extreme range of the pointer on the spring balance during the weighing of a given output never exceeded eight ounces, and it is believed that the error in reading the mean or average of such variations could not exceed two ounces, representing a maximum error of one-quarter of a horsepower in the determination of the mechanical output. The electrical input was measured in the usual way, the testing equipment consisting of

One 7½-kilowatt Weston wattmeter, connected through a multiplying Y-box with a ratio of 5 to 1;

One Thomson inclined coil 600-volt voltmeter;

One Thomson 200-ampere ammeter, and a

40-ampere Thomson switchboard ammeter, together with a portable tachometer.

All of these instruments had been recently calibrated with standard instruments and were believed to be correct. Whether this is so or not in an absolute sense was immaterial for the purpose in hand, since the instruments themselves were rated for known loads through the friction brake, and when used to determine the electrical input must indicate, under similar line conditions, the same ratio between input and output. A special switchboard was designed for these tests, each leg having a separate knife switch with a by-pass plug connection, so arranged that the wattmeter and ammeter could be cut in series on either leg, and successive readings from the three legs could be obtained in thirty seconds, the connections to the voltmeter being shifted at the same time. Four observers took the records, one at the brake, one with the tachometer, one for the volt and ammeters, and one for the wattmeter. Readings were repeated on each leg to avoid errors. The special arrangement for securing accurate electrical data was devised by Mr. Frank T. Whorff, superintendent for the Power Development Company, who, with his assistant, Mr. George Correa, made and recorded all the electrical measurements taken.

The resulting curves for efficiency and power factor are shown in Figure 1. If the tests had been made with a transmission dynamometer after continuous operation of the motor, until the full heating effect had been developed, the efficiency curve would probably fall off somewhat from the results shown under test conditions, with the motor practically cold; but as the pump tests were only a few minutes in duration, the condition of the motor was practically the same as when under test, and the curve correctly represents the output for similar conditions within the limits of error indicated by the observations themselves.

Four runners were delivered to us by the contractor for testing, all of the enclosed type, 18 inches in diameter, with vanes and waterways designed to suit the contractor's ideas of the changes from ordinary practice essential to successfully meet the new conditions. The vane curves and other dimensions are shown in Figure 2. Two of the runners were made with 10-inch suction inlets for use in a standard No. 10 shell, which, as ordinarily used, is equipped with a 24-inch runner. Ports were cut through the runner from the suction side into a balance ring, cast in the bottom plate of the pump, to partly equalize the disproportion of area exposed to discharge pressure on the upper and lower side of the runner, but leaving by construction an unbalanced excess of upward pressure, which in operation proved to be downward. The other pair of runners were cast with 8-inch inlets without balance rings and intended to have the same degree of curvature, but through inadvertance were given slightly larger waterways than the No. 10 runners. An 8-inch shell was provided for these runners with a close-fitting joint between the throat of the pump and periphery of runner, which made it possible to alter the thrust by raising or lowering the runner, the small, unbalanced resultant, either up or down, being carried on collars working against balls running in oil in a vertical thrust bearing. When starting, the entire weight of the rotor, shafting, runner, and couplings rested on the ball bearings, but as soon as discharge pressure was obtained most of this weight was counterbalanced by the upthrust of the runner.

The pumps were set up on the bank of the Kern Island Canal, and were connected with double 10-inch suction and a 10-inch discharge pipe which delivered the water horizontally into a deflecting box shaped like the letter Y, with a hinged gate operating through an acute angle and opening and closing either outlet simultaneously. One outlet connected into a galvanized iron measuring tank, and the other allowed the discharge to waste back into the stream. The gate could be operated in a fraction of a second in admitting water to the tank. Time was taken with a stop-watch reading to one-fifth of a second, and the accuracy of the apparatus is indicated by the fact that in four successive measurements of the same flowage the variation in time was only two-fifths of a second in 42 seconds, or something less than one per cent.

The static lift was measured direct from the surface of the water to the center of the horizontal discharge pipe, and the sum of the static and friction resistances was obtained from the readings of a pressure gage on the discharge pipe above the outlet elbow graduated to single pounds and a vacuum gage on the suction pipe graduated to inches. These gages were tested and found correct immediately before being used and the proper correction for relative vertical position was made. The same switchboard and electrical instruments were used in the pump tests that have already been described in connection with the motor tests, and the motor was the same one that had been subjected to brake tests. The setting of the pump

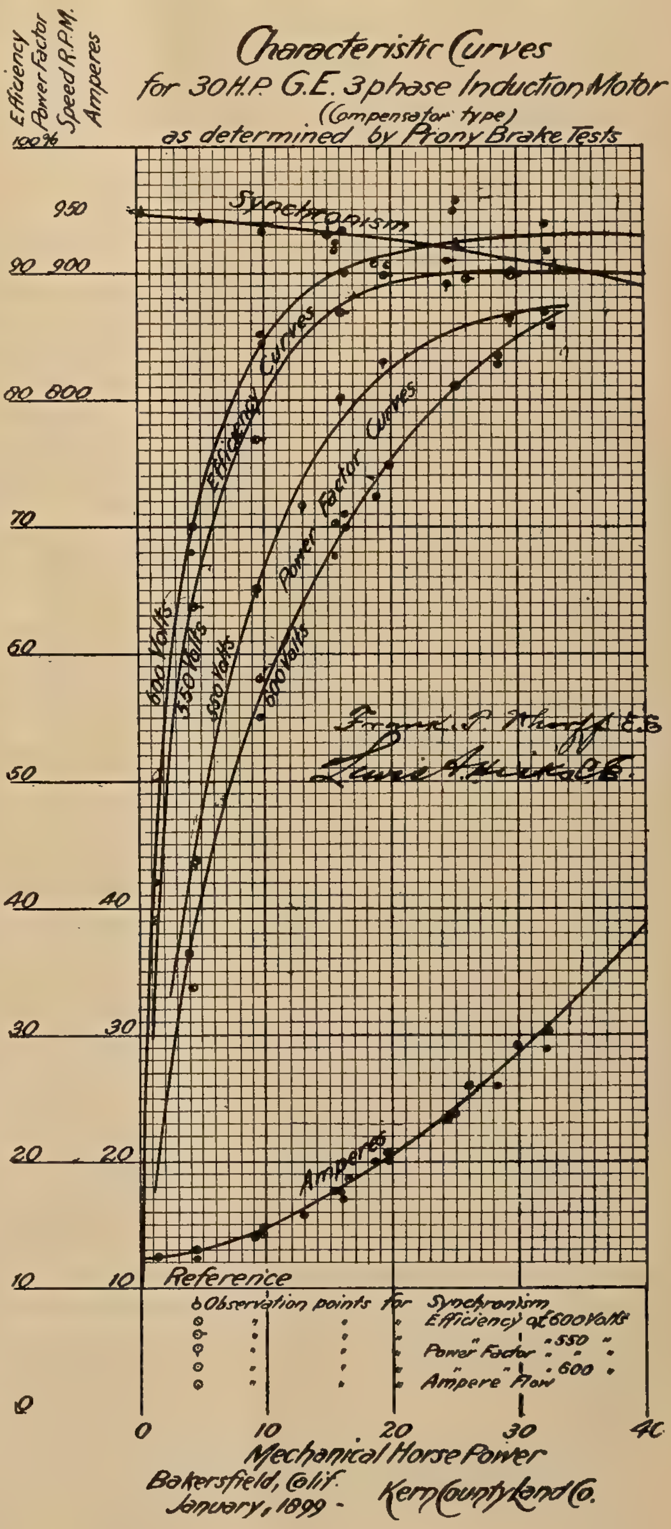


FIGURE 1.—HICKS ON CENTRIFUGAL PUMPS.

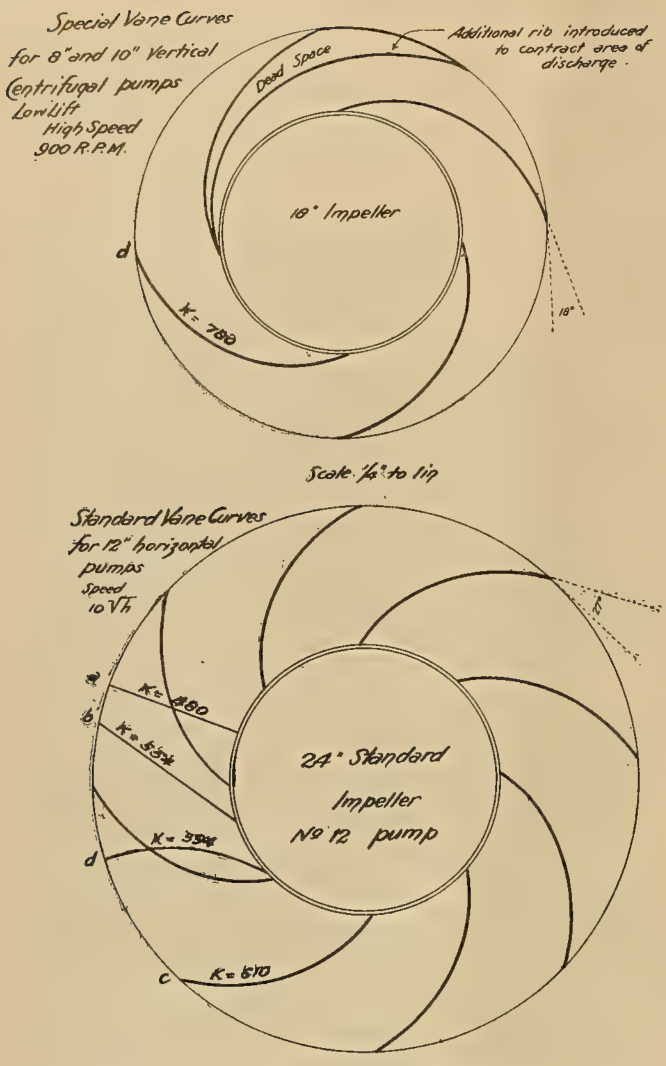
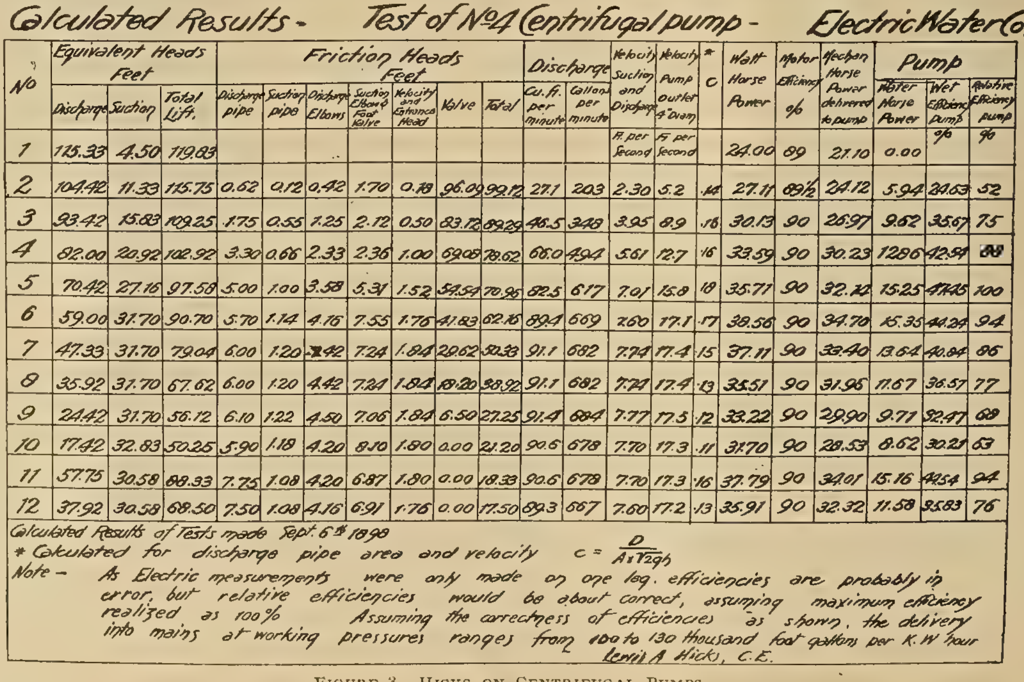

Special Vane Curves for 8" and 10" Vertical Centrifugal pumps
Low Lift
High Speed
900 R.P.M.
Additional rib introduced to contract area of discharge
Dead Space
18" Impeller
d
K = 780
18°
Scale-¼" to 1in
Standard Vane Curves for 12" horizontal pumps
Speed 10√h
a
b
K = 880
K = 554
d
K = 394
c
K = 610
24" Standard Impeller No 12 pump

FIGURE 2.—HICKS ON CENTRIFUGAL PUMPS.

and motor together with the arrangements for measuring the discharge will be understood from the accompanying photographs. The observed data and calculations resulting therefrom are given in the accompanying tabulations which are believed to be self-explaratory. There is included in this tabulation the test of two horizontal shaft centrifugal pumps belted to induction motors, which may be taken as representative of the results obtained in previous installations. The motors were of the same type and output as the one for which curves are given, and the testing apparatus was identical, except that a measuring weir was used to determine the discharge in place of a tank. The weir was built with a thin iron lip to conform to the Francis experiments, and the coefficients derived from those experiments for flow without end contractions were used to calculate the discharge. It will be seen from the efficiencies shown that the contractor was entirely successful in his undertaking, but the marked improvement over the No. 12 pump with ordinary commercial runner is largely due to the disproportionate size of the pump with reference to available water supply. The insufficient water supply also led to the throttling of the discharge pipe to balance the runner, and, as will be seen from the column, "discharge-pipe friction," this one item probably amounted to ten per cent. of the expended energy. The belt-friction load probably amounted to another horsepower. Allowing for these resistances, the writer has reason to believe that the net efficiency of the standard runners when pumping their rated capacity is substantially the same as the special runners.



Calculated Results - Test of No 4 Centrifugal pump - Electric Water Co.

No	Equivalent Heads Feet			Friction Heads Feet							Discharge		Velocity Suction and Discharge	Velocity Pump outlet 4" Diam	* C	Watt Horse Power	Motor Efficiency %	Mechan Horse Power delivered to pump	Pump		
	Discharge	Suction	Total Lift.	Discharge pipe	Suction pipe	Discharge Elbows	Suction Elbow & Foot Valve	Velocity and Entrance Head	Valve	Total	Cu. ft. per minute	Gallons per minute							Water Horse Power	Wet Efficiency pump	Relative Efficiency pump
1	125.33	4.50	119.83										ft. per Second	ft per Second		24.00	89	27.10	0.00	%	%
2	104.42	11.33	115.75	0.62	0.12	0.42	1.70	0.18	96.09	99.12	27.1	203	2.30	5.2	.14	27.11	89½	24.12	5.94	24.63	52
3	93.42	15.83	109.25	1.75	0.55	1.25	2.12	0.50	83.12	89.29	46.5	348	3.95	8.9	.16	30.13	90	26.97	9.62	35.67	75
4	82.00	20.92	102.92	3.30	0.66	2.33	2.36	1.00	69.08	78.62	66.0	494	5.61	12.7	.16	33.59	90	30.23	12.86	42.54	88
5	70.42	27.16	97.58	5.00	1.00	3.58	5.31	1.52	54.54	70.95	82.5	617	7.01	15.8	.18	35.77	90	32.12	15.25	47.45	100
6	59.00	31.70	90.70	5.70	1.14	4.16	7.55	1.76	41.83	62.16	89.4	669	7.60	17.1	.17	38.56	90	34.70	15.35	44.24	94
7	47.33	31.70	79.04	6.00	1.20	4.42	7.24	1.84	29.62	50.33	91.1	682	7.74	17.4	.15	37.11	90	33.40	13.64	40.84	96
8	35.92	31.70	67.62	6.00	1.20	4.42	7.24	1.84	18.20	38.92	91.1	682	7.74	17.4	.13	35.51	90	31.95	11.67	36.57	77
9	24.42	31.70	56.12	6.10	1.22	4.50	7.06	1.84	6.50	27.25	91.4	684	7.77	17.5	.12	33.22	90	29.90	9.71	32.47	69
10	17.42	32.83	50.25	5.90	1.18	4.20	8.10	1.80	0.00	21.20	90.6	678	7.70	17.3	.11	31.70	90	28.53	8.62	30.21	63
11	57.75	30.58	88.33	7.75	1.08	4.20	6.87	1.80	0.00	18.33	90.6	678	7.70	17.3	.16	37.79	90	34.01	15.16	44.54	94
12	37.92	30.58	68.50	7.50	1.08	4.16	6.91	1.76	0.00	17.50	89.3	667	7.60	17.2	.13	35.91	90	32.32	11.58	35.83	76

Calculated Results of Tests made Sept. 6th 1898

* Calculated for discharge pipe area and velocity $c = \frac{D}{A \times \sqrt{2gh}}$

Note – As Electric measurements were only made on one leg. efficiencies are probably in error, but relative efficiencies would be about correct, assuming maximum efficiency realized as 100% Assuming the correctness of efficiencies as shown, the delivery into mains at working pressures ranges from 100 to 130 thousand foot gallons per K.W hour

Lewis A Hicks, C.E.

FIGURE 3.—HICKS ON CENTRIFUGAL PUMPS.

Granting that any centrifugal pump, with enclosed runner, may be adapted to high-speed work by suitable alterations of the runner, considerations of convenience and compactness in setting and operation, as well as economy in deterioration of belts and bearings, settles the question in favor of the vertical form, and, as a result of these tests, contracts have been made for the manufacture of eight such pumps and vertical shaft motors, to be installed by the Kern County Land Company.

There is another outlet for power consumption by centrifugal pumps, which in Bakersfield, we owe to Mr W. L. Dixon, engineer for the Electric Water Company. This company made its installation under his advice and now pump the entire domestic water supply of Bakersfield with two No. 4 centrifugal pumps direct-connected to induction motors. These pumps are situated about half a mile apart and discharge directly into six-inch mains without any connection to a stand pipe or tank, and maintain a hydrostatic pressure of 30 to 45 pounds in the mains. As originally installed, one of these pumps discharged into a 50,000-gallon tank at an elevation of 70 feet, from which the city supply was drawn by gravity. But it was soon found that better service was secured by pumping directly into the main, and at present the tanks are only used for reserves in case of temporary shut down of the power.

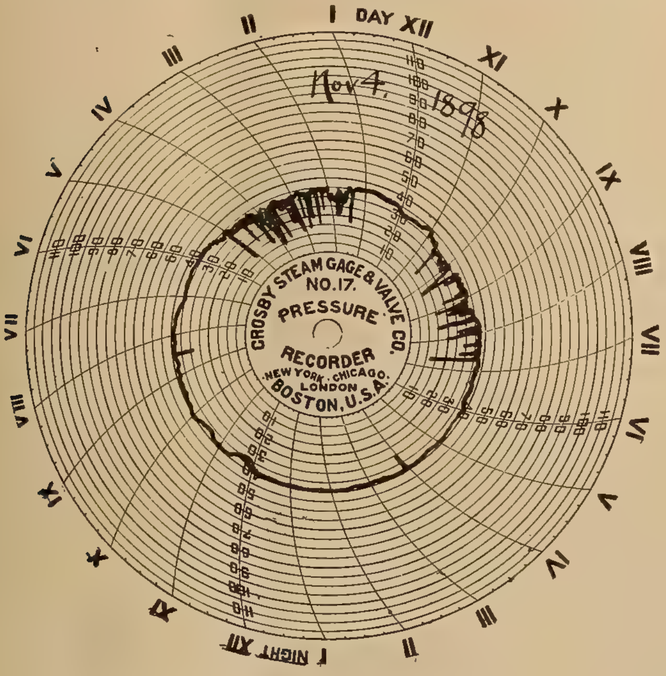


FIGURE 4.—HICKS ON CENTRIFUGAL PUMPS.

The local flour mill has been operated for some years past by means of a turbine, taking water from a gravity canal. This wheel has been connected up to a motor-generator, which, in case of accident, is run as a generator supplying current to the city pumps, or in case the water is diverted into other canals it takes current from the lines of the Power Development Company and drives the mill. This constitutes the main reserve. The pumps regulate themselves, delivering under a remarkably steady pressure whatever quantity is called for by the draft on the pipes. If the draft increases, the volume pumped automatically increases as the pressure decreases, and if the draft were to cease entirely, by the closing of all cocks the only effect at the pump would be to slightly increase the pressure. Figures 4 and 5 are sample sheets from the daily record of an automatic gage on one of the pumps, showing the normal working variations in pressure. The sudden fall in pressure for a small time interval, making almost a straight line on the diagram, represents the opening of a three-inch valve to supply city sprinkling carts.

Certain interesting facts develop in connection with the operation of these pumps.

It was pointed out to the writer about a year ago by Mr. Edward S. Cobb, of San Francisco, that for constant speed the discharge of a centrifugal pump for any lift varies with the square root of the difference between the actual lift and the hydrostatic head created by the pump without discharge. If any centrifugal pump connected to a source of supply and to a discharge pipe of considerable height is put in revolution, it will be found that it is necessary to maintain a certain peripheral runner speed to hold the water one foot high without discharge, and that for any other height the requisite speed will be very nearly as the square of the velocity for one foot. One of our most reliable mechanical hand-books states that the peripheral runner velocity in feet per minute required to hold water to any height without discharge is equal to 500 $\sqrt{h}$, basing the statement on experiments with the Appold pump, and making no qualfication whatever as to the form of the vane, but treating the matter as though the constant 500 is suitable for any and all centrifugal pumps.

Other experiments prove, however, that the speed necessary to lift water to a given height with vanes of the form shown in diagram No. 8 is approximately as follows:

a	481 $\sqrt{h}$
b	554 $\sqrt{h}$
c	610 $\sqrt{h}$
d	780 $\sqrt{h}$
e	394 $\sqrt{h}$

It appears then, that instead of being a constant for all pumps, this number varies with the shape of the vanes, and as this means that different speeds are necessary to hold water to the same heights with these different forms of vanes, it follows that for any constant speed or lift there must be a form of vane more suitable than any other. It would seem at first glance that the runner which creates a given hydrostatic head with the least peripheral velocity must be the most efficient, but practically it is apparent from the tests heretofore described that the curvature of the vanes can be designed to suit the speed and lift without materially lowering the efficiency.

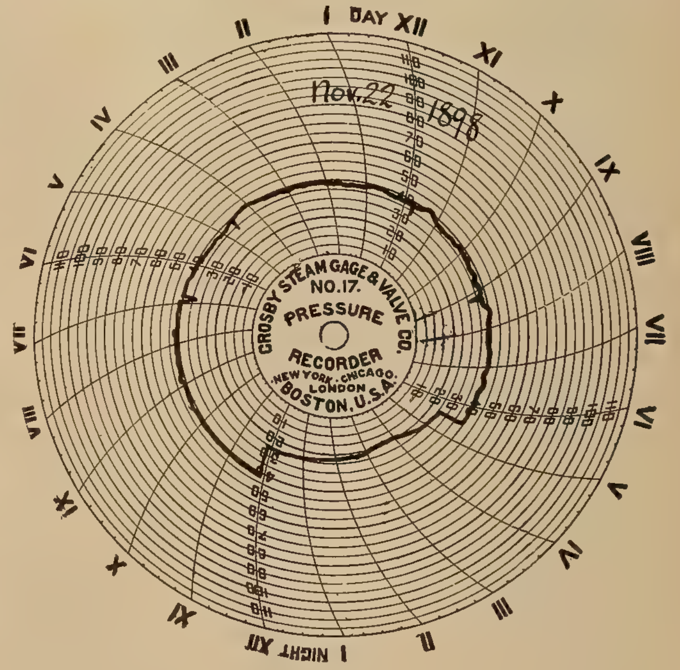


FIGURE 5.—HICKS ON CENTRIFUGAL PUMPS

Consider any horizontal shaft centrifugal pump so connected to a source of supply that the level of the water would be maintained at the top of the runner, and provided with a vertical discharge pipe of greater height than the hydrostatic head which the pump can create at the speed at which it is to be operated, and of relatively larger diameter than the pump outlet. Let K = the peripheral speed per minute necessary to raise water one foot without discharge with the form of vane used, and V any other peripheral speed per minute; then the height H, at which water will be held without flow in the discharge pipe, will be represented by the expression

$$H = \frac{V^2}{K^2} \qquad \text{Figure 8.}$$

Now suppose an opening relatively small as compared to the diameter of the pump outlet to be made at a distance h below the level where the water is held. It is evident that following the well-known laws of flow through orifices, discharge will take place in proportion to the square root of $h - h_2$, multiplied into suitable coefficient of efflux and the area of the opening, and that the height at which water is held will drop down in the pipe by an amount h_2 equivalent to the head necessary to overcome the frictional resistances created by the velocity of flow into and through the pump and aurifice. If the entire height h is used in the ordinary formula for discharge,

$$D = A \times c\sqrt{2gh}$$

instead of the correct height $h - h_2$, then the reduction of head due to the creation of velocity, the resistance to entry of the foot-valve and of passage through the pipes and pump openings, will take the form of a lower coefficient, and the variations of this coefficient for different values of h and D will furnish some indication as to the variation of frictional resistances in the pump. In other words, c represents the ratio which the actual discharge for any head h bears to the theoretical discharge, and includes all sources of loss. If the resistances were constant at all heads, then for constant value of A, D would vary as the $\sqrt{h}$. But, if for any reason, the net sum of the resistances change, the coefficient will also change. The numerical value of the coefficient is of no importance, because it would be relatively large or small, depending on the size of opening used.

Data of Tests.

No	Size of Pump	Connection	Impeller	R.P.M.		Static Lift			Gages			Electric				Discharge				
				Motor	Pump	Suction	Disch.	Total	Vacuum	Pressure	Correction for Position	Leg	Volts	Amps	Watts	Time	Tank	Leakage	Weir	Total
						Ft.	Ft.	Ft.	Inches	Lbs	Ft.					Seconds	Galls			Galls
1	No 10 Vertical	Direct	18" Inclosed Open *	915	915	7.18	24.03	31.21	9	12	-.13	A	550	37¼	10425	43⅗	1878	27		1905
												B	550	36	10090					
												C	550	36	10090					
2	No 10 Vertical	Direct	18" Inclosed Contracted	925	925	6.68	24.03	30.71	775	11.46	-.13	A	547	26¼	7050	67⅗	1878	34		1912
												B	546	25.5	6675					
												C	545	26.5	6925					
3	No 12 Horizontal	Belted	24" Inclosed Standard	925	546	23.33	8.09	31.42	22	5⅔	-.50 +2.17	A	600	27	8800				5 5/16"x50"	
												B	584	34	9875					
												C	584	28	7550					
4	No 8 Vertical	Direct	18" Inclosed Contracted	925	925	5.43	24.57	30.00	6	11	-.50 +1.08	A	541	26	6425	64	1878	31		1909
												B	542	25	6185					
												C	547	27	6800					
5	No 8 Vertical	Direct	18" Inclosed Open	920	920	5.43	24.57	30.00	6½	11¼	-.50 +1.08	A	540	37½	10175	41	1878	42		1920
												B	540	35	9675					
												C	540	36.5	10175					
6	No 8 Horizontal	Belted	24" Inclosed Standard	930	549	21.08	10.00	31.08	21½	3.9	-.33 +2.12	A	556	14	4525				4 3/16"x50"	
												B	555	23	6275					
												C	552	14	5475					

* Full peripheral discharge

Results

No	Pipe Friction			Total	Discharge		Pump Velocities					Motor Input Watt H.P.	Motor Efficiency	Pump Input. Mechan H.P.	Pump Output H.P due		Pump Efficiency	
	Suction	Discharge	Total	Equivalent Lift	Gallons per minute	Cu Ft. per Second	Suction	Discharge	Periphery of Impeller	$\sqrt{2gs}$	$6\sqrt{h}$				Static Lift	Total Lift	Static Lift	Total Lift
1	2.98	3.51	6.49	Ft 37.70	2621	5.84	5.36	10.72	71.82	1.61	12.93	41.02	90%	36.92	20.71	25.02	56.1	67.8
2	2.07	2.20	4.27	34.98	1697	3.78	3.47	6.94	72.65	1.63	13.09	27.68	89	24.63	13.19	15.03	53.6	61.0
3	1.59	6.62	8.21	39.63	1831	4.08	5.19	5.19	57.17	1.27	10.20	35.15	92.5	32.51	14.57	18.37	* 44.8	56.5
4	1.36	1.12	2.48	32.48	1790	3.99	3.66	7.32	72.65	1.65	13.25	26.02	89	23.16	13.60	14.73	58.7	63.6
5	1.93	1.93	3.86	33.86	2810	6.26	5.74	11.48	72.26	1.64	13.17	40.24	90	30.22	21.30	24.09	58.8	66.5
6	3.27	0.75	4.02	35.10	1369	3.05	5.59	6.97	57.50	1.29	10.86	21.95	88	19.32	10.77	12.16	55.7	62.9

* Throttled discharge

FIGURE 6.—HICKS ON CENTRIFUGAL PUMPS.

The experiments, of which Figures 6 and 7 give the data and results, were made with a No. 4, standard pattern, horizontal shaft centrifugal pump, direct-connected to a 30-horsepower motor and in daily use for water-works service. The discharge through a six-inch pipe was connected into a measuring tank with a swinging elbow to waste-way. The pressure head was obtained by use of a valve on the discharge, the results being checked at several points by the use of a standpipe. It was possible to measure the suction depth directly, and the total resistances were shown by vacuum and pressure gages. The hydraulic data was taken with great care, equal in all respects to the tests heretofore described, but it was only possible to secure electric measurements on one leg, and the pump efficiencies are consequently valueless as exact statements, as there was no certainty that the load on the three legs was balanced. Nevertheless they are of considerable importance in showing the relative efficiency which may be expected at different lifts in terms of the maximum efficiency for given speed. The total hydrostatic head was secured by closing the valve on discharge pipe and taking the sum of the heights represented by the vacuum and discharge pressure as the value of H. The valve was then opened far enough to lower the pressure five pounds and the discharge was measured. Then another five-pound drop in pressure, and so on throughout the possible range of observation. The height h_1, representing the sum of static and frictional resistances at any point of discharge, has been calculated from gage readings for each point of observation. Also the value of the coefficient c has been calculated for the same points from the measured discharge, and with a value of $h_1 = H - h$. If the hydrostatic head H is drawn as a straight line, and the discharges in gallons per minute are platted as ordinates from the heights corresponding to the points of observation, and the extremities of these ordinates are connected, then will any ordinate to the curved line so formed represent the discharge at that height. Consider the nature and magnitude of the friction resistances in a centrifugal pump with an enclosed runner.

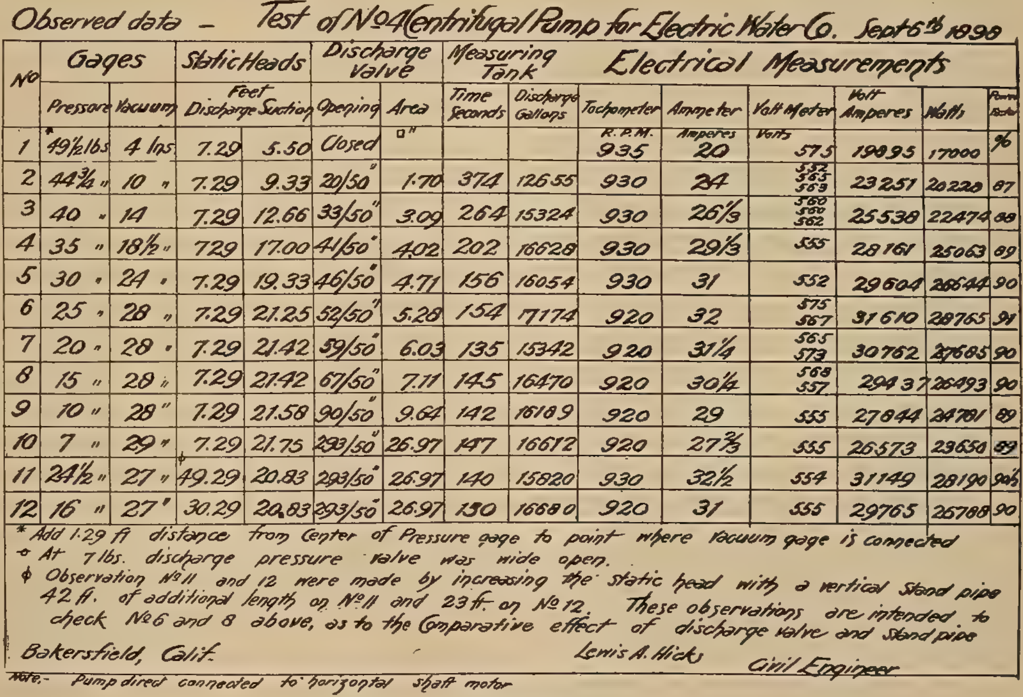
When maintaining a hydrostatic head without discharge, there are four principal sources of loss; namely:

First. The slip or back circulation around the suction inlet caused by the leakage of water from the discharge under a head due the static lift. As ordinarily manufactured, with leakage on both sides of the runner, and an opening of $1/32$-inch around the suction inlet and balance ring, or when the bearings have worn slightly, this one item may account for 20 per cent. of the lost work. It evidently decreases with the height of lift.

Second. The frictional resistance of the circulated water across the side plates and through the vanes of the runner, approximately as the square of the velocity of flow, and as the flow is proportionate to the $\sqrt{h}$, this item also decreases with the lift.

Third. The drag of the runner periphery revolving at a high speed in water practically without velocity. The speed of the runner experimented with was 83 feet per second. When discharge is taking place the water in the throat and volute of the pump will attain a velocity proportionate to the area. Assuming, for instance, a velocity of flow of 15 feet per second in the same direction as the runner, this loss would be decreased approximately in proportion as 68^2 is to 83^2, the difference representing about 40 per cent. of the original resistance. As this loss decreases with the increase in velocity of flow, it evidently decreases with the lift.

Fourth. The friction of the side plates of the runner with the water in the pump shell. Since this is independent of pressure it will be a constant quantity for any height of lift.



Observed data — Test of No. 4 Centrifugal Pump for Electric Water Co. Sept 6th 1898

No	Gages		Static Heads Feet		Discharge Valve		Measuring Tank		Electrical Measurements					
	Pressure	Vacuum	Discharge	Suction	Opening	Area	Time Seconds	Discharge Gallons	Tachometer	Ammeter	Volt Meter	Volt Amperes	Watts	Power Factor
						□"			R.P.M.	Amperes	Volts			%
1	*49½ lbs	4 Ins	7.29	5.50	Closed				935	20	575	19895	17000	
2	44¾ "	10 "	7.29	9.33	20/50"	1.70	374	12655	930	24	552 565 563	23251	20228	87
3	40 "	14	7.29	12.66	33/50"	3.09	264	15324	930	26⅓	560 560 562	25538	22474	88
4	35 "	18½ "	7.29	17.00	41/50"	4.02	202	16628	930	29⅓	555	28161	25063	89
5	30 "	24 "	7.29	19.33	46/50"	4.71	156	16054	930	31	552	29604	26644	90
6	25 "	28 "	7.29	21.25	52/50"	5.28	154	17174	920	32	575 567	31610	28765	91
7	20 "	28 "	7.29	21.42	59/50"	6.03	135	15342	920	31¼	565 573	30762	27685	90
8	15 "	28 "	7.29	21.42	67/50"	7.11	145	16470	920	30¼	568 557	29437	26493	90
9	10 "	28 "	7.29	21.58	90/50"	9.64	142	16189	920	29	555	27844	24781	89
10	7 "	29 "	7.29	21.75	293/50"	26.97	147	16612	920	27⅔	555	26573	23650	89
11	24½ "	27 "	ϕ49.29	20.83	293/50"	26.97	140	15820	930	32½	554	31149	28190	90½
12	16 "	27 "	30.29	20.83	293/50"	26.97	130	16680	920	31	555	29765	26788	90

* Add 1.29 ft distance from Center of Pressure gage to point where vacuum gage is connected

◦ At 7 lbs. discharge pressure valve was wide open.

ϕ Observation No. 11 and 12 were made by increasing the static head with a vertical stand pipe 42 ft. of additional length on No. 11 and 23 ft. on No. 12. These observations are intended to check No. 6 and 8 above, as to the comparative effect of discharge valve and stand pipe

Bakersfield, Calif. Lewis A. Hicks Civil Engineer

Note.- Pump direct connected to horizontal shaft motor

FIGURE 7.—HICKS ON CENTRIFUGAL PUMPS.

When discharge commences conditions are somewhat changed, since new elements of resistance are introduced. These are made up of the head necessary to create velocity of flow past the resistances offered by the pipes and pump passages, together with the kinetic energy lost in the form of discharge velocity. The sum of these resistances probably varies in a ratio somewhat less than the square of the velocity of flow, and therefore increases with a decrease in lift.

After discharge commences, it may be said in general that one source of lost work remains constant, three tend to decrease as the lift decreases, and one increases as the lift decreases. A careful consideration of the relative value of each of the factors of resistance, with due appreciation of the relative unimportance of fluid friction at low velocities, would, it is thought, lead to the conclusion that as the lift decreases the decrease in friction would be in excess of the increase due to velocity. This would continue until the increasing velocity friction throttles the discharge so that it ceases to follow an ascending ratio of the available head. This point may be called the breaking down point of the pump, or the point at which the discharge commences to represent a smaller percentage of the theoretical flow due to the area and the head, supposing the algebraic sum of the resistances a constant. In Figure 8 the theoretical discharge for different coefficients in gallons per minute has been platted as ordinates of the height of lift, and the variation in net resistance is clearly shown by the manner in which the line of actual discharge crosses the lines of constant resistance in an ascending ratio, attains a maximum, and then abruptly breaks down about the point where the velocity of flow through the discharge outlet of the pump becomes 15 feet per second.

You will notice that the experimental determination of flow amounts to rating the pump as a meter, so that the quantity being pumped into the main at any time may be ascertained from the reading of the pressure gage, and from the continuous record of an automatic gage, the daily flow may be computed with considerable accuracy.

If the discharge of a centrifugal pump at constant speed maintained a constant ratio to the head, the useful work performed would vary as the product of the weight of water discharged at any point into the height of lift. Expressed by formula,

$$\text{Useful work} = A \times c\sqrt{2gh} \times 62.5 \times h_1.$$

If the work for different heights is calculated by this formula and a constant value of c, and a curve is constructed by platting these values as ordinates to a line

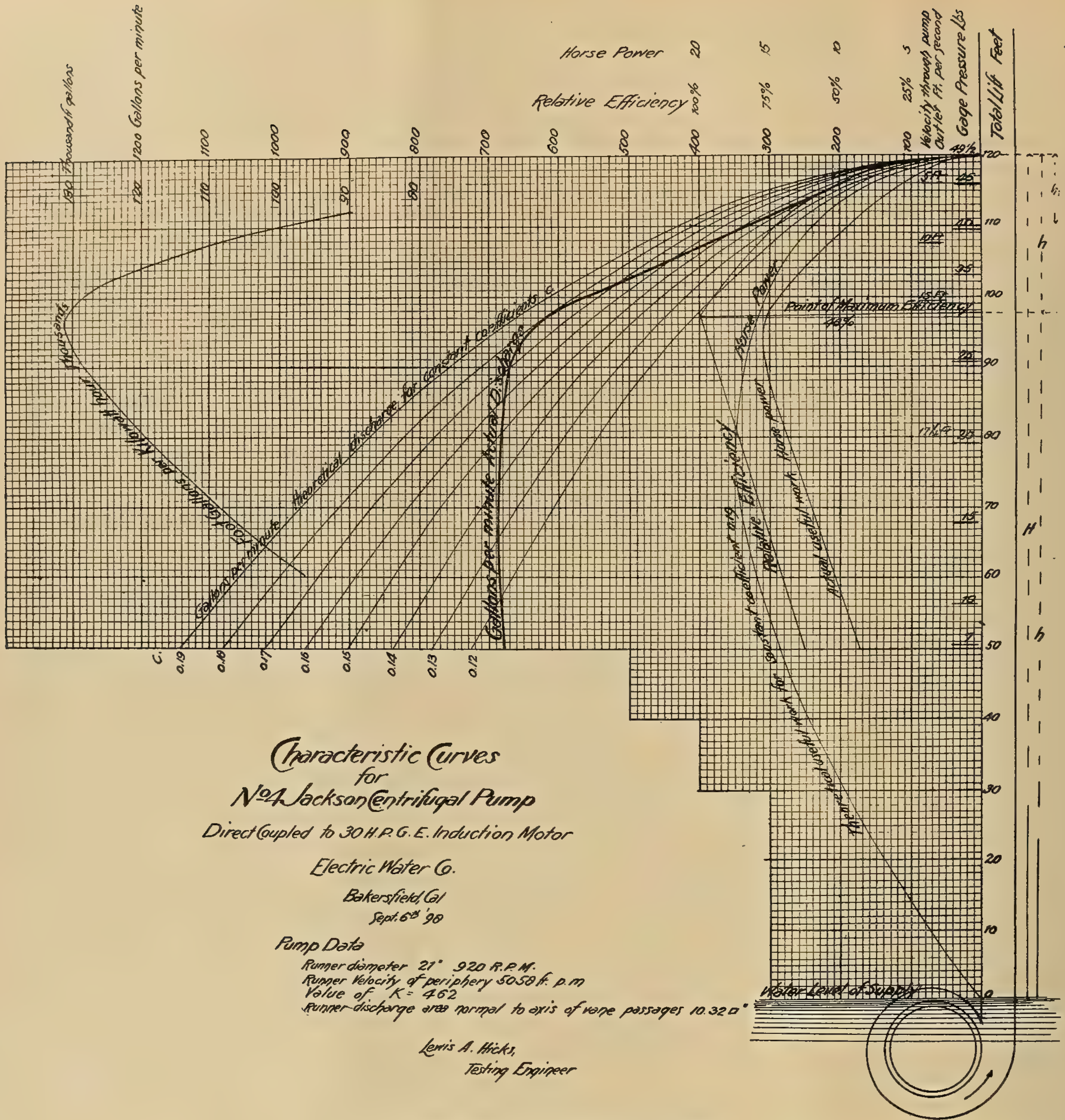


FIGURE 8.—HICKS ON CENTRIFUGAL PUMPS.

representing the hydrostatic head, it will be found that this will always assume the form shown in Figure 8.

h increases as h_1 decreases, and the mathematical relation is such that the curve will always attain its maximum at ⅔H, the total hydrostatic head, and if the resistances were proportionately uniform the maximum efficiency of the pump would be attained at the same point. In practice the maximum efficiency occurs at the breaking-down point of the discharge, when the ratio of discharge commences to decrease.

The actual work is shown in Figure 8, together with a curve of relative efficiency which is platted merely to show how closely it follows the curve of useful work in form and peculiarities. It seems evident, in view of this agreement, that if through favorable changes in the water ways of the pump, the discharge line could be maintained past the present breaking-down point, the efficiency would be very considerably improved. The actual efficiency may have been slightly more or less than shown, depending on how nearly the load was balanced in the three legs.

It is thought that the methods herein described offer a rational mode of investigating the so-called mysteries of the centrifugal pump, and that a wide range of observation along similar lines in the hands of competent designers may be expected to produce better pumps, which is the consideration that interests all of us. It is therefore with the idea of provoking discussion which may lead to a better understanding of the subject that the writer presents the tentative methods of analysis herein described.

Centrifugal pumps are commonly relegated to low lifts on the ground of inefficiency at high lifts. There appears to be no practical reason for this conclusion, and on the other hand the writer possesses experimental data which warrants the belief that efficiencies of 70 to 75 per cent. may be reasonably specified and required for lifts of 100 feet and over.

The length of time that this efficiency can be maintained in a given pump will depend on the amount of sand pumped, the excellence of the design and workmanship in the matter of minimizing back circulation and providing water-ways for low velocities, stiffer spindles, first-class bearings with self-oiling rings, a better grade of packing, and finally, upon the case with which the bearings are maintained and lubricated. The high speed of revolution makes it somewhat difficult to maintain packing successfully against vacuum pressure; but when purchasers demand a higher standard of excellence, and these matters receive the same intelligent care given to other machinery, there will be something of a revolution of opinion regarding centrifugal pumps. It is manifest from the tests submitted that the pump in use is not suitable for its work, and yet, with the low efficiencies shown, the results compare favorably with large high-duty plants elsewhere. The cost of pumping 1000 gallons to a height of 100 feet for fuel and attendance ranges from ½ cent to 1¼ cents for steam, and from ⅛ cent to ⅜ cent for water power. It will be seen from Figure 8 that at the ordinary working pressure in the mains, 130,000 foot-gallons were pumped per kilowatt-hour. Assuming capital invested in transmission plant at $250 per horsepower, and a load factor of 50 per cent., the probable cost of horsepower to the consumer would be not far from $50 per annum, or about ¾ cent per kilowatt-hour, making the cost per 100,000 foot-gallons about ⅝ cent. This could be improved with a pump adapted to its conditions to an average duty of 200,000 foot-gallons per kilowatt-hour, or at the rate of ⅜ cent per 100,000 foot-gallons.

Where cheap current is available and suction conditions permit the setting, a centrifugal pumping plant suitable to supply a city of 5000 people with motor, transformers and all equipment, including housing, can be installed for $2500. This would provide two pumps set on a common base on either side of motor, to which they would be direct-connected, with suitable by-pass connections so arranged that ordinarily the delivery would be directly into the main, the peripheral runner speed being adapted to create 40 to 50 pounds working pressure. In case of fire the opening and closing of a couple of valves would instantly run the pressure up to 100 pounds.

A duplicate plant could be installed for less than the ordinary investment in tank storage, and by leaving a pulley between the motor and pump, and a beltway to a gas or steam engine, the risk of interrupted service would be minimized. The consideration of relative first cost, and fixed charges so created, gives a yet more favorable showing. It is well known that the most economical pumping engine is not the one showing highest efficiency in terms of coal consumption, but that in which the sum of the fixed charges and coal cost is least.

The application of this philosophy to the centrifugal pump leads to the conclusion that a properly designed plant of this type in units up to 5,000,000 gallons capacity, is economically superior to any other installation; and that where circumstances are favorable to the use of electricity, the simplicity, compactness, and automatic regulation of these plants is unexcelled. Where steam is used, centrifugal pumps attaining an efficiency of 70 per cent., and connected to triple-expansion condensing engines, capable of producing an indicated horsepower-hour with 15 pounds of steam, may be expected to give a duty of 65,000,000 to 75,000,000 foot-pounds per 1000 pounds of steam, and, owing to the enormous difference in first cost, compare favorably in economic performance with high-duty machinery attaining a duty of 120,000,000 to 150,000,000 foot-pounds and a mechanical efficiency of 95 per cent. These considerations must, in time, make the centrifugal pump an important factor in water-works service.

*Electric Lighting versus Gas.**

BY JOHN MARTIN.

WHEN I became interested in electric lighting some four years ago, due to an investment in a water transmission plant furnishing light and power, the subject of proper rates for illumination became a matter of investigation for me, which I have continued up to the present time. This investigation brought me in contact with gentlemen operating both gas and electric plants, whose opinions were so greatly at variance that it became almost compulsory to experiment in order to obtain anything definite as a proper basis for the service rendered. The conclusions which I have reached are based upon personal experience, which may be of some interest to others, at least to the extent of bringing out a discussion from practical sources which may lead to a better understanding of this great problem that is ever present to managers of lighting plants.

Unbounded enthusiasm and blind prejudice were so strongly embedded in the minds of many managers of both electric and gas plants, that very little was accomplished in the matter of a fair and straight adjudication of rates and service until they came in contact with the opposing method of illumination, usually brought about by consolidation. This enabled the opponents to get a proper appreciation of the merits and shortcomings of the previously opposing method of artificial illumination.

---

*A paper read before the Third Annual Convention of the Pacific Coast Electric Transmission Association, San Francisco, June 20-21, 1899.

When electric lighting was first introduced, it was the custom for the promoters to load the plant with excessive first cost, and, comparatively, very inefficient apparatus. The results then obtained caused the gas men to become confident that electric competition would not be serious. So true was this that when the Welsbach burner was first presented to them they spurned it as an evil to be avoided, for by its use the consumer's bill would be decreased.

After some years of evolution the electric installation has been greatly perfected, its cost materially reduced and its efficiency very largely increased. The gas men in self-defense took up the active use of the Welsbach burner, which to-day is their greatest help in competing with incandescent electric lighting.

The usual methods previously in use in competition were such that when a company would establish very low rates for one kind of artificial illumination, the manager of the opposing company would either decide that the opponent would surely go into insolvency at a moment's notice, or resort to the usual method of making a reduction for his illuminant. This was usually persisted in by both companies until each lost money in the sale of current or gas for illuminating purposes. Both sides became content with a false idea that they were pursuing the proper course because they saw nothing but failure ahead for their competitor, whereas, at the same time they failed to appreciate their own unfortunate losing situation. The many losses sustained in this vicious method of competition usually resulted in a consolidation of interests, and after a thorough knowledge of both methods of illumination, these companies have since become profitable without excessive rates being charged to the consumer.

When competition presents itself at this day, the wise manager makes it a business to study closely the full strength of his adversary, and if a vicious competition is unavoidable, he considers it his duty to arrange his rates to give at least a small profit to his company, if by doing so he can compel his adversary to suffer loss. If, on the other hand, he finds that competitive rates would cause his company a loss, and at the same time were high enough to enable the opposition to make a profit, he then considers it his duty to make the first advance looking towards a consolidation, or a working arrangement with his adversary whereby both can live.

In determining the question of rates, the following fact is usually lost sight of in assuming the ability of your adversary to maintain low rates, namely: *Low rates are always conducive to largely increased consumption.* Larger output insures reduced cost of production, so that when a gas plant cannot pay with its present consumption at less than $3.00 per thousand, yet with a quadrupled consumption it can pay at $2.00 per thousand; or an electric plant hardly paying expenses at 20 cents per thousand watts, may under similar conditions of increased output pay handsomely at 12 cents per thousand watts.

Several months ago I addressed communications and questions to many managers East and West, asking for information as to rates, character of installation, competition and success of competing companies, from which I will quote (without specific reference), and at this juncture desire to express my thanks to all for their kindness and consideration in giving the information asked for and their ideas of policy.

As this paper is being submitted mainly for the consideration of the proponents of electric lighting, I desire to present several opinions as expressed in answers to the following query:

In your judgment what plan is best to adopt to successfully cope with gas competition, and at what prices for gas is your plan based?

Among the answers I received the following:

From a large New York plant:

Gas, 95 cents per thousand. Incandescent lights, 20 cents to 10 cents per kilowatt-hour.

In my judgment, to compete with the Welsbach, we should avoid too active a campaign as it would tend to excite the gas interests to great activity. The Welsbach's popularity is soon lost owing to decreasing candlepower, disagreeable light, and short life of mantles.

From a New Jersey plant:

Gas, $1.50 per thousand. Electric light, 13½ cents per kilowatt-hour.

Low rates and good service, with enough business enterprise to call the attention of the public to the decided advantages of electricity as an illuminant, will easily meet gas competition. If all houses in our territory were wired, we would have little difficulty in securing most of them as customers, because wiring old houses stands in the way of our getting many customers who are otherwise anxious for the light.

From a Massachusetts plant:

Gas, $1.25 per thousand. Incandescent light, 23 cents to 12½ cents per kilowatt-hour.

We compete quite successfully with gas at prices named, by giving good service and the conveniences of electric light over that of gas. Also the fact of electricity being more healthy.

And a few selections from Pacific Coast plants:

The best plan is to consolidate; if not, fight fire with fire by the installation of a modern gas plant as an adjunct.

With small consumers, namely, residences, suggest flat rate based on a specified number of lights burned at one time with an overload meter or overload vibrator for excess.

Good service and low rates. Rates to be about equal to gas rates, candlepower for candlepower. There are large separate fields for both gas and electricity.

From these answers it is fair to assume that the average electric lighting company is on a progressive and profitable basis, but it should not be inferred that gas plants are not. The reduction in prices of gas for fuel has opened a very large and profitable field for the gas companies heretofore unoccupied by them, which has compensated partially, if not wholly for the loss of sales for illumination. Such being the case, the increased production of gas for heating purposes has prompted the gas companies to lower their rates for illumination, generally without specific losses. It is therefore unwise for managers of electric plants to believe that gas plants are on the decline, and in a condition bordering on decay. While it may be, and is probably true, that enormous profits are a thing of the past, yet with good active management a gas plant may continue in business without serious loss, in competition with an electric plant, if properly managed and every legitimate economy adopted. From this I do not desire the gas man to establish false hopes in the theory that if they can at least make a small profit now, they may eventually hope to make a larger profit in the future.

The improvements in the electric service are so marked and rapid that there is little hope left for the gas plant as a very profitable competitive illuminant, unless working arrangements are made with the opposing company.

I will now consider from a theoretical standpoint the two methods of artificial illumination.

The candlepower of illuminating gas that is furnished throughout the United States ranges from 16 to 20 candlepower, and I have assumed 18 candlepower as the value of the average gas so furnished, burning 5 feet per hour in an open burner.

The consumption of a 16 candlepower incandescent lamp ranges from 50 watts to 70 watts per lamp, and I have assumed 60 watts as an average consumption for a 16 candlepower lamp. The average consumption of gas through a 4-foot tip is approximately 6 feet per burner per hour. The consumption of gas through a Welsbach burner averages 3 feet per hour per burner. The average candlepower of a Welsbach burner is 42 candles.

With the use of an open-tip burner 1,000 feet of gas consumed will produce 3,600 candle-hours. In the use of a Welsbach, 1,000 feet of gas will burn 333 1-3 hours, producing 14,000 candle-hours.

In order to produce a theoretical equivalent of illumination, the 16 candlepower incandescent lamp will have to burn 225 hours to equal the consumption of 1,000 cubic feet of gas through a common-tip burner, which aggregates 13½ kilowatt-hours, and in theoretical competition with the Welsbach burner, it would have to burn 875 hours, consuming 52½ kilowatt-hours of electric current.

On this theoretical basis, with gas at $1.50 per thousand, using a common-tip burner, electric current should be sold at 11 1-9 cents per kilowatt-hour. If gas is $2.00 per thousand, at 14 8-10 cents per kilowatt-hour. Gas at $2.50 per thousand, 18 2-10 cents per kilowatt-hour, and gas at $3.00 per thousand, 22 2-9 cents per kilowatt-hour.

The theoretical rate in competition with the Welsbach with gas at $1.50 per thousand, current should be sold at a little less than 3 cents per kilowatt-hour, and a proportionate increase for the higher prices of gas.

From the above it is obvious that the open burner cannot successfully compete on the Pacific Coast with the incandescent lamp, and it may be assumed that the Welsbach burner holds a mortgage on efficient illumination.

While the above figures are based entirely on theoretical equivalents, there are practical conditions which effect the proportions to such an extent as to introduce a personal equation. These conditions can be summed up as follows:

Among the objections to Welsbach lighting, as determined by the consumer, are, first, decreasing candlepower; second, disagreeableness of the light changing from incandescent white to a yellowish green; third, brittleness of the mantles; fourth, difficulty in lighting; fifth, limited sphere for decorative effect; sixth, vitiation of the atmosphere. These objections permit the sale of current for incandescent lighting at higher prices because of a large number of consumers who are willing to pay a little more for illumination, when the above objections are eliminated, as is the case with the use of the incandescent lamp.

The personal equation above named also makes the use of Welsbachs permissible, for there are a number of consumers who are willing to submit to the objectionable features enumerated and thereby effect a financial economy in illumination.

The conditions existing on the Pacific Coast, where a large amount of electric illumination is produced by use of water power, and current is sold at flat rates, the question of cost of illumination in competition with Welsbachs is very largely removed. The rates charged in California for residence purposes will average 25 cents per 16 candlepower lamp per month, 24 hours service, and 80 cents per light per month for business purposes.

The eastern managers as a rule, and some of our western managers, believe firmly in the sale of current by meter measurement exclusively, while California managers have established flat rates almost entirely. It is a fact that the only satisfactory basis for selling current produced with fuel is on meter basis, and many managers also argue that all illumination should be so charged.

From the standpoint of a manager of a water-power installation, I must take issue with the latter contention. When current is produced by a water-power plant (and by this I mean a plant having ample water power for its installation through the entire twelve months of the year), the establishment of the flat rates has proven satisfactory in many plants in California. It has the one advantage of eliminating disputed accounts. Each patron knows in advance what his light bill will be, which is alike satisfactory to business men and housewives. The restriction in extravagant use of current with flat rates is the life of the lamp, the renewals for which the customer pays.

By making very low rates per lamp installed, the home is wired more liberally, and my expereince demonstrates that the low rates for residence use has increased the consumption per lamp very materially. This means better illumination for more hours per day, than when sold by meter measurement. The old habit of turning off the light to effect economy, has vanished, and with it comes the fortunate disease of good, liberal illumination. This disease becomes infectious, until finally the entire town is afflicted. This affliction is indeed a blessing; the homes are more cheerful and pleasant, and at the same time the feeling of extravagance is not experienced.

Admitting that the only restraint in consumption is the cost of renewals, the question arises as to what compensation does the electric company obtain for its service. From personal experience I find that with an average of 500 consumers at residence rates, the amount of current furnished equals 38 per cent. of the total capacity of the lamps installed. Assuming an average residence rate of 25 cents per 16 candlepower lamp, we obtain an average revenue approximating 66 cents per lamp current per month, or about $7.00 per horsepower per month. This leaves the current available for day service power, which can be disposed of on a profitable basis. It is true that some plants are selling power in large units at from $5.00 to $10.00 per horsepower per month for 24-hour service. From this it is evident that illumination at these low rates is profitable even after paying the additional interest on the investment, and the depreciation, cost of maintenance, operation and repairs of the distribution system. In business houses the rates are necessarily higher, because all lights are used at the time of peak load. This peak load is the determining factor of the capacity of the plant. The development of the day service for power at some plants produces an average 24-hour load factor ranging from 70 per cent. to 80 per cent. of the peak load.

Hints on Long-Distance Transmission.*

BY R. W. VAN NORDEN.

IN stringing the wire for the new circuit between the Auburn power house, recently erected, and Sacramento, the supply of large triple-petticoat glass insulators gave out and temporarily standard two-petticoat glass insulators with teats, were used to support a mile of wire. These latter were closely watched, especially in wind and rain. While the former often cracked or split, and in some cases set poles on fire, the ordinary insulators showed no signs of weakness. Locust pins were used, and as an extra precaution every pin was boiled in paraffine until thoroughly soaked. So far as can be ascertained by careful observation there has been no cracking, splitting or leakage, and no arm or pin has been burned or charred. The line has been cut out and thrown in suddenly every day for nine months; but while the water in a storm hangs from the teats and drips near the wire or upon the arms, no results detrimental to the proper working of the line have been observed. Several large glass insulators have passed through severe storms without accident, though badly cracked. It is therefore a natural conclusion that boiling the pins in paraffine is of extreme importance.

The possibility of synchronizing the machine at Auburn with the Newcastle generators, the distance between the stations being some five and one-half miles, and the line of No. 4 copper wire, was seriously questioned by some authorities, who claimed that as the capacity of the line was small, the effect would be to cause a current lag or a change in the form of the electromotive force curve and make the machines pump or altogether fall out of synchronism. Not the slighest difficulty of this nature was experienced. In fact when Station No. 2 comes in, the operator at Station No. 1 hardly knows the moment, there being only a slight movement of the ammeters.

At present all regulation (the system is hand regulated) is done at Station No. 1. Station No. 2 starts up with a specified load, and as the general load increases, at a telephone signal Station No. 2 augments its own load 100 horsepower at a time, every hour or half hour, until the maximum is reached. The operation is then reversed until Station No. 2 is cut out entirely.

By this method no water is wasted at Station No. 1, where it is valuable for irrigation, etc., while at Station No. 2 the water must flow constantly, this station being on the same canal but farther up the country.

If for any reason the generator in Station No. 2 be underexcited, the difficulty can be remedied by overexciting the lower generators. This causes a slight flattening of the electromotive force curve, however, so that a wattless current flows between the stations, which tends to make the voltmeters fluctuate very slowly but regularly about one volt; and the ammeters become unsteady.

The distance seems to have a cushioning effect and it is not by any means so necessary to have the generators so near in synchronism when thrown together, as when side by side.

It is therefore evident that stations may be distributed over considerable distance and yet run as one, all aiding to swell the total of current to be delivered.

---

*A paper read before the Third Annual Convention of the Pacific Coast Electric Transmission Association, San Francisco, June 20-21, 1899.

On the Determination of a Fair Return for Current Supply.*

BY C. WM. HUTTON.

THE question of a proper method of arriving at a schedule of charges for current supply is vexed and unsettled, but certainly one that will repay close investigation. The prevailing practice seems to be a sort of intelligent guesswork on the part of the majority of electric companies.

In dealing with a subject of this kind it will be found impossible to lay down any fixed method that will cover all cases, but at the same time, by the method herein proposed, it will be found that the same general principles of arriving at the cost of current supply will hold good in any case, and thus enable an electric company to establish rates, which, when applied, will make each customer, as near as possible, a profitable adjunct to the station. This general plan has already been proposed in connection with steam plants supplying current, and is not, therefore, original with the writer. I find, however, that it is particularly applicable in the case of waterpower transmission plants, and will therefore present it for your consideration.

To establish this rate, which varies with each plant with local conditions, it is necessary only to know the average of the peak load for the several months of the year that the station in question is called upon to carry during the year, the drop and current losses between the switchboard and the customer during this load, the interest charges including dividends, the proper charges for depreciation on the whole system, the general expense charges, which may be assumed to be fixed, and the average generating and delivering cost per kilowatt-hour. The sum of the interest and dividend, depreciation and general expense charges for the year represents the total fixed charge. The average peak load, less the current and copper losses, will represent the customer's average demand at peak load, and the former divided by the latter expressed in kilowatts gives the fixed charge per annum for each kilowatt actually used at peak load.

Assume for the purpose of illustration a waterpower transmission plant of say twenty miles, which has an average peak load throughout the year of 3,530 kilowatts at the sub-station distributing switchboard. The capacity of the generating machinery for such a load should not be less than 4,500 kilowatts allowing for all contingencies.

Assume the cost of the electrical equipment of such a plant to be	$300,000.00
The waterpower development, including water-wheels and accessories	250,000.00
The distributing system from sub-station (overhead lines)	100,000.00
Lands, buildings, etc	100,000.00
Franchises and other property	50,000.00
Making a total investment of	$800,000.00

Allowing 6 per cent. for interest and dividends on this amount, we have	$48,000.00
Depreciation at 4 per cent. on the whole system	32,000.00
The general expense account, including salaries of officers, accounting and office expense, legal expense, collection, canvassing, taxes, insurance, etc., would probably not be less than	46,000.00
So that the total fixed charge per annum would be	$126,000.00

The average maximum switchboard load having been 3,530 kilowatts, and the loss in *distribution* at this average load being taken at 15 per cent., the customer's average maximum demand would be about 3,000 kilowatts, so that each kilowatt supplied at this maximum would be chargeable with $126,000.00 divided by 3,000, or $42.00 per annum to cover the so-called fixed expenses, and each customer who uses all his connected load should pay this sum per kilowatt capacity wired, as well as the actual cost of current delivered for each kilowatt-hour supplied to him. This price will be prohibitive to the customer who uses service only for a very short period at the time of maximum load, but public policy requires the company to supply all applicants who can pay for the service, and at a price, in this case, not to exceed, say 10 cents per kilowatt-hour, so that the loss sustained through this class must be made up from the customers who use current more continuously. This may appear unjust, but in reality it is less so than the ordinary system of charges, by which a customer having twenty lamps, and using them all ten hours per day, pays the same rate as the customer having two hundred lamps connected and uses them only one hour per day. The latter is the most unprofitable customer, and should pay the maximum rate, while the other is entitled to a liberal discount.

The method here suggested of determining the rate which can profitably be made to such customers is based upon the length of time they use the current. If, for example, in the plant described, the average cost of generating and delivering a kilowatt-hour (based on the assumption that we have a delivered load factor of fifty per cent., and that the actual operating expenses outside of those above enumerated is $2,700.00 per month) is one-fourth of a cent, and a customer who burns all his lamps should have twenty lamps, or one kilowatt capacity connected, and consumes 250 kilowatt-hours in a month, his bill would be one-twelfth of $42.00, or $3.50 for fixed charges, plus $62\frac{1}{2}$ cents for generating cost, or a total of $\$4.12\frac{1}{2}$, making a rate of $1\frac{3}{4}$ cents per kilowatt-hour consumed. If the same customer's meter showed a consumption of 125 kilowatt-hours for the month, he would have averaged one-half of the hours burning as in the previous instance, but he would be charged $3.50 as before for fixed charges, plus $31\frac{1}{4}$ cents for generating cost, or a total of $\$3.81\frac{1}{4}$, which would make his rate slightly over three cents per kilowatt-hour consumed. In both cases he has paid the interest and depreciation on that portion of the investment necessary to supply him his share of the general expenses and the cost of generating the current he has used. The rate per kilowatt hour of monthly consumption for each kilowatt capacity called for at peak load can be readily determined from a curve constructed from the data of each individual plant.

---

*A paper read before the Third Annual Convention of the Pacific Coast Electric Transmission Association, San Francisco, June 20-21, 1899.

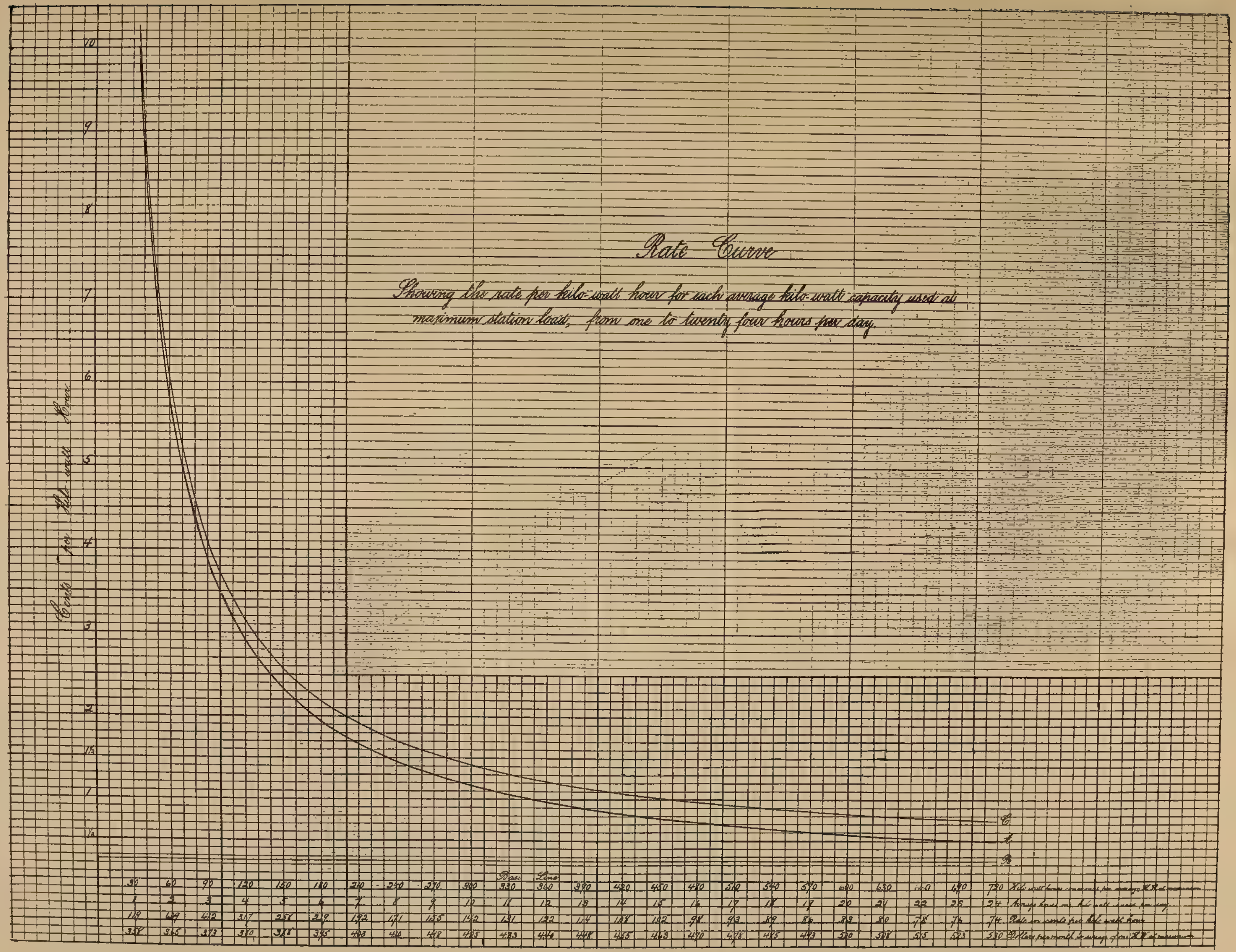
The accompanying curve gives the charges under the conditions existing in the station used for illustration. The kilowatt-hours on monthly meter readings per kilowatt capacity called for at peak load is laid off horizontally, and the cost in cents per kilowatt-hour vertically. A curve, *A*, is first plotted, the ordinate for any point of which is determined by dividing $3.50 (one twelfth of the annual fixed charge) by the abscissa in kilowatt hours. A horizontal line, *B*, is then drawn through the point in the vertical scale, expressing the average generating and distributing cost in cents per kilowatt-hours, in this case one-fourth of a cent, and the sum of these two, curve *C*, gives the rate per kilowatt-hour for any monthly meter reading. In order to ascertain the proper rate for a customer who calls for more or less than one kilowatt capacity at peak load, the monthly meter reading should of course first be divided by the kilowatt capacity he uses.

It will be seen that by this system for determining the minimum rate at which day customers (and long-hour night customers as well) can be profitably supplied applies equally to those having very few lamps or very small motors as to those having large installations, and by extending its principles to such small capacity consumers with relatively high monthly consumption, a very large amount of business, which is to-day compelled to use other illuminants or other sources of power, might be taken on the electric companies' circuits with profitable results. These rates, as shown by the curve, are necessarily power rates, being based on the assumption that the obligation of the company ceases with the delivery of the current on the premises of the customer. If, therefore, as is customary with a great many electric companies, lamp renewals are furnished, or in the case of arc lighting, the average extra cost of the same per kilowatt-hour should be added to the power rates.

One point in particular in connection with the rate curve is very noticeable, and that is that a customer using small capacity, but showing a relatively high monthly consumption, either for light or power, would be charged at an exceedingly low rate per kilowatt-hour. In fact, a rate that would be so very much lower than the rates of any other possible method of furnishing illumination or power that a considerable advance could be made in the rates to such customers and still destroy all competition by other methods. The revenue from such source can therefore be made to compensate in a measure for such loss as would be sustained through furnishing current to the short-hour customer with a heavy demand.

The very important question then arises as to what form of current-measuring apparatus shall be used to carry out the principles of this system of charges. The ideal meter would, of course, be one that would show the customer's average maximum demands in kilowatts, together with total number of kilowatt-hours consumed during the month. An attachment has, I understand, been recently put on the market which, when used in connection with a watt-hour meter, will register the customer's load for each day on a moving strip in such a manner so that the *average* maximum for the month can be readily obtained, which, together with the watt-hour reading, will be all that is required. Another recent device has also been brought out, whereby the *maximum* demand is indicated by the use of the ordinary forms of watt-hour meters, to which the above device is attached. The maximum demand being indicated by making use of the torque exerted by the armature on the drag disc. The upper or motor part of the meter, carrying an indicator, is flexibly coupled to the lower or drag portion, which consists of a disc on which is plotted the kilowatt scale. A pawl and ratchet prevents the relaxation of the spring, so that the device indicates the maximum kilowatts that has passed through the meter during the month. This latter device would, therefore, answer the same purpose as the well known combination of a Wright demand indicator, when installed in connection with a regular watt-hour meter, but with the advantage that the two instruments are combined in one. Still another method that has recently been advocated is the use of two-rate wattmeter, by which method a customer is charged at a higher rate for consumption during the peak load hours than for other hours. These three latter devices are good in a way, as they tend to keep down the peak load, and in a double way increase the load factor, for it not only *keeps down the peak load*, but *encourages the long-hour customers*, and especially will this be so in the case of distribution from a water-power electric transmission as against electrical distribution from a steampower plant, because of the relatively high fixed charges as compared with generation and distribution charges in the case of the former.

This fact is so very noticeable that it would appear that a flat rate based on the average demand of the ordinary class of customers could be made that would answer all purposes, and it can if some method be devised whereby it is possible to know the customer's average maximum demand. I say *average*, because it would not be right to charge a customer who may want



30	60	90	120	150	180	210	240	270	300	330	360	390	420	450	480	510	540	570	600	630	660	690	720	Kilo-watt hours consumed per average K.W. at maximum
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Average hours use kilo-watt used per day
119	609	422	317	257	219	192	171	155	142	131	122	114	108	102	98	93	89	86	83	80	78	76	74	Rate in cents per kilo-watt hour
358	365	373	380	388	395	403	410	418	425	433	440	448	455	468	470	478	485	493	500	508	515	523	530	Dollars per month to average of one K.W. at maximum

to use, say, double the amount of current for a few hours at some particular time during the month on the basis that such double load is his daily demand, excepting, of course, the case of a store which closes early five nights in the week and remains open during the entire peak load hours on the sixth night. Such cases will require special rates; in any case, that will depend to a considerable extent on other conditions. The great objection to placing any of the measuring devices that are known to the writer on the premises of each and every customer is the excessive cost of all present forms. As has been shown, any device which will enable the charges to be based on the average maximum demand has the tendency of *keeping down the peak load,* which is of the utmost importance, and increasing the load factor. It will be seen, however, that increasing the load factor of the average customer would be of very little advantage to the electric company, as it would increase the revenue from these customers but slightly; for increasing the total load factor of the entire system from fifty per cent. to one hundred per cent. would halve only the one component of the total cost, viz.: the generating and distributing cost—in this case one-fourth cent per kilowatt-hour, which, in any event, would be a very small portion of the average customer's bill; and even in the case of a power customer using his power, say twenty-four hours per day and twenty-six days in the month, it would decrease the total cost of his power less than sixteen per cent.

From what has been shown, the following conclusions may be drawn as to what method shall be used for determining a fair return for current supplied by waterpower electric plant where the conditions approximate those given in the plant used for illustration, having roughly the following class of customers to supply:

Class 1. Those which use current for power purposes from eight to twenty-four hours daily in units of more than five kilowatts capacity.

Class 2. Those which use current for motors of less than five kilowatt capacity and for lighting stores, saloons, residences, etc., using the current for from two to twelve hours daily, and are always on during the peak load hours.

Class 3. Those which use current for lighting large early-closing stores, which close at six o'clock on five of the week day nights and remain open until ten o'clock the sixth night.

Class 4. Those which use current under a special contract which stipulates certain hours that the current may be used for the purpose of keeping their load off during the peak load hours.

For customers coming under the head of class one, an instrument should be provided that will not only indicate the number of watt-hours consumed during the month, but should also give an indication from which it would be possible to arrive at the customer's average maximum demand for the same period. With these figures at hand, and by reference to the price curves, the proper rate per kilowatt-hour will be determined.

For the majority of customers who would come under the head of class two, a simple and comparatively cheap device is required. In one form an instrument could be made which could be set to carry a predetermined amount of current which would be sufficient to supply the customer under ordinary conditions, but that would open the circuit if a greater amount were drawn for any length of time, and would close the circuit again, remaining closed providing the maximum current for which the instrument is adjusted is not exceeded. In addition to this, the instrument should be provided with an attachment which would enable the customer at his own discretion to change the adjustment so as to allow him to use a greater predetermined amount of current for such time as he may desire, the attachment being so arranged that in changing the adjustment he would wind and set in motion a simple clockwork that would register the number of hours during the month he had used the current while the instrument was adjusted for this increased demand. An instrument of this kind in a mechanical form, such as a circuit breaker, could be cheaply made up about as follows: The brake would be made by a solonoid, drawing out the switchblades against the tension of a spring, the solonoid being actuated by means of the expansion of a metal strip designed to carry the supply current, making such a contact that the solonoid would be thrown in circuit and thus open the switch. The load being off, the metal strip would immediately cool and the contraction of the same would open the solonoid circuit, thus allowing the spring to close the switch, when current would be supplied as before. The opening of the circuit would, of course, be an indication to the customer that he was using more current than for which he had contracted.

On the side of the instrument would be arranged a rack rod, which, when pushed in once, would shunt the metal strip with a given resistance, and at the same time wind and put in motion a simple clock device connected to a train of gears on which would be arranged hands that would indicate on a dial in hours. One push on the handle would run the clock device for one hour, when it would release the shunt, restoring the instrument to its original adjustment, the clockwork stopping at the same time. If it was desired to use extra current for two or more hours, he would push the rack two or more times, as desired, thus winding the clock sufficiently to run the desired number of hours. The company would thus be enabled to know that the customer's ordinary demand did not exceed a certain amount, and also the number of hours he had exceeded this amount. Another form of instrument, that would be somewhat simpler, and perhaps less likely to get out of order, would be the well known

Wright demand meter, with the addition of a clock mechanism and shunt attached to the meter on the same general lines as in the instrument already described.

For those customers who would come under the head of class three, a demand indicator would be required that would give such a reading that it would be possible to obtain the customer's maximum demand for each day in the month. Customers of this class are the very worst with which the electric companies have to contend; but as the revenue from such sources is an inviting plum, it will always be found desirable to take them on the circuits, though this business in itself would represent a loss were it not possible to make up such loss from the customers who use the current more continuously.

The customers under the head of class four are the most flexible and desirable of any, as they can be used to fill in the hollows of the load line in any way desired. They are a class that belong almost exclusively to the electric companies, who, as a general rule, transmit their energy several miles over pole lines, running through fertile farming country. Especially is this true in this State, in which the vast valleys are used in nearly every instance for agricultural purposes. The principal uses to which power will be put would, therefore, be for the purpose of running irrigating pumps. As these customers would be kept off during the peak load hours, what revenue would be obtained from them would be practically a clear profit. Very low rates could, therefore, be made which would be an encouragement for extended usage. Their charges would therefore be on a basis of a certain price per kilowatt-hour, regardless of their demands. The ordinary form of watt-hour meter would, in these cases, answer all purposes.

In offering these suggestions of a method of establishing a rate, it is not claimed that it will exactly fit each individual case, but the application of its general principles will fit any case, especially the plan of constructing a rate curve from the data of each individual plant, as herein outlined, as it would enable any electric company to ascertain whether and to what extent some of its doubtful customers represent a profit or a loss, and to guard against making unprofitable contracts in the future.

LONG SPANS OF OVERHEAD WIRES.

According to Professor Juellig, the maximum spans possible for wires of different materials on a basis of a factor of safety of 4 is as follows:

Cast steel wire	3.42 miles
Silicon-bronze	1.56 to 1 mile, depending on quality
Wrought iron	1.02 miles
Soft copper	0.53 miles

These maximum spans are independent of the cross-section of the wire, for although the weight of the wire increases with the cross-section, its strength increases in the same proportion. The spans given do not allow for wind pressure, snow or ice.

Illumination

ELECTRIC RAILWAY TRAIN LIGHTING.

THE most remarkable feature in the revival of electricity for train lighting is that it has been mainly caused by one system, the invention of A. B. Gill. So widely has it appealed to railway men that already it is in use on upwards of one hundred railways, including several American railways. The details of a method which has practically created a revolution in the illumination of trains is obviously of interest. In its essential feature it consists of a dynamo placed underneath the carriage, being driven from the axle. To merely drive a dynamo from the axle of the carriage is one of the oldest arrangements in train lighting. It was done on the Midland, on the Brighton and South Coast and in Australia many years ago. But it is not difficult to conjure up the difficulties that such a method must contend against. All systems that embrace driving from the axle must provide some means of meeting the variation in speed of the train. It is in the manner of solving that problem which gives to the various systems their distinctive characteristics.

The simplest method that would occur to an electrician, says H. Scholey in *Cassier's Magazine*, would be to utilize the excess current generated by increased speed, to partially demagnetize the field magnets, thus keeping the output of the dynamo within certain definite limits. This formed the basis of more than one method, but they each necessitated delicate means of governing, and this was partially responsible for their comparative failure.

In the Stone system there is a complete departure from this method of compensating for speed variation. The dynamo is suspended from the under frame of the carriage in such a position that its driving pulley is practically on a level with the axle pulley, from which it is driven by a belt. By such means it is claimed that none of the vibration or vertical motion of the axle is transmitted to the dynamo. The substantial difference between this and former systems is that, no matter how great may be the variation of speed, the dynamo always runs at a fixed speed, and consequently produces practically a constant amount of electricity, and this is achieved in a comparatively simple manner.

The dynamo is suspended from the carriage by one corner, and is held by means of an adjustable link in such a manner that it is free to swing. When connected by means of the belt to the axle pulley, the link may be so adjusted that the driving belt draws the dynamo out of its natural position. This adjustment is regulated to give a definite tension on the belt sufficient to absorb power equivalent to the amount of electricity required. In other words, it is possible by means of the adjusting screw attached to the suspending link to set the machine to supply a certain definite number of lights. In endeavoring to seek its natural position the dynamo exerts a pull on the belt. As long as the axle pulley runs within the certain limits, its pull on the belt is no greater than that of the dynamo; when, however, the train increases its speed the axle exercises a greater pull on the belt, and this has the effect of drawing the dynamo towards the driving pulley, with the result that the belt slips while the armature continues to revolve at its normal speed. Increased speed means more slip, and in that we have the secret of this system of train lighting.

"Several of the engineering papers from the JOURNAL have been read and discussed before the assembly of the National Association of Stationary Engineers here with profit," writes the secretary of the San Diego, Cal., association in renewing his subscription.

It is an unexplained, but indubitable fact, asserts the *Gastechniker* that acetylene kept in its holder for some days falls off in lighting power, and that this deterioration is well marked even after twelve hours.

An electric automobile has attained a speed of 63.6 miles per hour in France, the record being made for the second kilometer in a run of two kilometers.

THE JOURNAL OF ELECTRICITY, POWER AND GAS

Devoted to the Conversion, Transmission, and Distribution of Energy.

Conducted by GEO. P. LOW.

Official Organ of the Pacific Coast Electric Transmission Association.

Yearly subscription: Domestic, $1.00; Foreign, $1.50, postage paid.

Published monthly at 320 California Street, San Francisco, Cal.
Address remittances and communications to
315 CHERRY STREET, [Telephone, "Pine 76"] SAN FRANCISCO, CAL.

VOLUME VIII JULY, 1899 NUMBER 1

For Table of Contents see Page XI.

EDITORIAL.

THE POLICY OF THE JOURNAL.

The change which is apparent in the title of this publication in the present issue, is due to several causes, the most particular one resting in the fact that the interests it has fostered so long are of a composite rather than of a specific nature. *The Journal of Electricity* has not excluded from its columns all save that which pertains to electrical matters. It has devoted great space to considerations of the applications of hydraulics, of steam power and of the gas engine; these not only as prime movers but each in its own peculiar fitness in the attainment of the golden goal of highest possible efficiency. Compressed air, too, has received due consideration, for its importance in the constellation of transmission agencies is far from being inconsequential. Above all, modern engineering does not purport a blind devotion to electricity or gas or steam or pneumatics; but instead, the adaptation of either or several or all these as may best satisfy the conditions existing to most eminent fitness.

Say what one will, a publication devoted to a specific channel of engineering must inevitably, though perhaps innocently and unconsciously, become biased in its advocacy of the interests it represents. Are there gas papers that discuss the electric light with absolute fairness, or electrical publications that do not retaliate? Are there journals devoted to compressed air that do not depreciate the electric motor, or, *per contra*, electrical magazines which rise above their secular animosities and endorse compressed air as a motive power in instances wherein it is inherently the best fitted for such? Similarly, and to illustrate the point more forcibly, are there water wheel manufacturers frank enough to admit that conditions requiring a moderate distance electric transmission from a waterfall may exist wherein the installation of steam would be profitable, and the utilization of the energy of the waterfall would be a commercial failure? Of these, there may be some, but they are numbered among the hopeless minority.

Better is it then, by far, that a publication which aspires to and actually attains an absolute impartiality in its treatment of the respective merits of the natural agencies for the conversion, transmission and distribution of energy, should be forever freed from whatever might restrict the utterance of unprejudiced opinions. Capital is seeking profitable investment the world over, and the new problems constantly arising, together with the almost kaleidoscopic changes being made in some branches of engineering development, lend further emphasis to the necessity stated.

It has thus been determined to broaden the title of the JOURNAL that its true aim and scope may be more clearly defined.

IT MEANS BUSINESS.

At last the monopoly which has held the electric lighting business of San Francisco in its grip ever since the inception of the industry, is to be broken, for the man who has the hardihood and cash with which to offstand the assaults of the sugar trust and to bring it to its terms; who has the courage and power to drive the entering wedge that, in the Valley Road, is soon to release the relentless grasp of the Southern Pacific Company upon the throat of the mercantile interests of California; the man who almost, if not quite above all others, has time and again proven his unfaltering loyalty and devotion to the advancement of the interests of the Golden State, has said that the electric lighting monopoly in San Francisco is to be broken as soon as men, money, and human ingenuity can do so. More than that, he has put his own resistless shoulder in earnest to the wheel, and this is what has resulted:

On March 28th of the present year, the Independent Electric Light and Power Company was incorporated; but prior to that date its plans were well matured. Within three months thereafter contracts had been awarded for machinery and construction work amounting in the aggregate to more than two million dollars, and the preliminary work of the installation is now progressing with the greatest possible speed consistent with thoroughness and the best engineering practices. It is expected that the new system will be in operation early during the coming winter.

When the projected plant is in operation, San Francisco will possess an installation that will be a noteworthy electric transmission as well as a central station which will be the peer, if not the superior, of any in the world. In brief, steam power generated on the water front will be electrically transmitted to sub-stations by three-phase, high-potential, underground conductors, and from these sub-stations the various characters of service will be run underground, first to the business sections of the city and afterward to the residence portions.

To be explicit: The generating station will occupy the block bounded by Twenty-third, Humboldt, Louisiana and Georgia streets, adjoining the California Sugar Refinery, in Potrero, San Francisco. The contract awarded to the Babcock & Wilcox Company provides for the early installation of eight batteries of the well-known Babcock & Wilcox double-deck boilers of wrought steel construction, and having a capacity, according to the Centennial rating, of 6000 horsepower. Each of the eight batteries will consist of three such boilers, or 24 boilers in all, and the boiler plant will be operated so that there will always be two batteries in reserve. Induced draft will be used and an equal capacity in Green economizers and Stratton separators and receivers will be erected under the original contract. The engine equipment will consist of three $\frac{28 \times 58}{48}$ vertical cross-compound McIntosh & Seymour engines, running at 116 revolutions per minute and delivering 2400 horsepower each with 165 pounds of steam. Each engine is guaranteed to deliver 4200 horsepower under $^{6}/_{10}$ cut-off. In addition, two $\frac{9\frac{1}{2} \times 19}{15}$ vertical tandem McIntosh & Seymour engines, each running at 210 revolutions per minute and delivering 150 horsepower, are to be installed.

The electrical machinery is to be that of the Westinghouse Electric and Manufacturing Company throughout. Direct-connected to each of the three larger engines is to be a 1500-kilowatt revolving armature, 500-volt two-phase generator, while the two smaller engines will each drive similarly a 150-kilowatt, 125-volt engine-type exciter. The plant will operate at 60 cycles. Seven 750-kilowatt transformers will take the the two-phase generator potential and deliver it to the underground mains at 11,000 volts in three-phase current. Three, or possibly four, sub-stations will be installed in the business sections of the city, involving a transmission of between four and five miles. The sub-stations will contain lowering transformers delivering 2200-volt three-phase current for the operation of rotaries, and for direct delivery to the underground distribution at that electromotive force. Direct-current 110-volt, three-wire distribution will also be made under the Lamme system* as in use notably in the Hartford and San Gabriel transmissions. In addition to driving the larger sizes of polyphase motors direct, the 2200-volt three-phase underground mains will operate transformers in the manholes for supplying the low-tension alternating distribution circuits. The installation of direct-current series arc lighting circuits is not contemplated at present—although it may be done—as it is believed that the alternating-current enclosed arc lamp has at last reached the stage of commercial perfection. Obviously, the 2200-volt mains may supply transformers for the delivery of any desired potential or phase from any of the manholes, which, with the direct-current circuits from the sub-station, will enable the delivery of any class of service desired. The "block" system will be generally adhered to in the low-tension distribution, and the manhole transformers will ordinarily run in 100, 50, and 25 kilowatt sizes. Lead-covered multiple cable will be used exclusively in the original work, and the contract awarded for this aggregates approximately 2,000,000 feet. The contract for the entire underground conduits and subways provides for the placing of sewer tile conduits, laid in cement. The only overhead work at present contemplated is a line extending from the Potrero power house to the power house of the San Francisco and San Mateo Electric Railway Company, at Sunnyside, a distance of nearly five miles. Power delivered by this proposed line will drive rotary converters for the operation of the street railway system, thus displacing its present more or less antiquated steam plant.

These are the general features of the system under which the Independent Electric Light and Power Company is to operate, and that they will be adhered to is evidenced in the fact that their installation is contracted for. Engineers will be quick to recognize that the designers of the new plant have, in general, thoroughly grasped the trend of modern central station design; but some will take exception to the use of step-up transformers, with their consequent losses, when the delivery of 10,000 or 12,000 volts at the terminals of the generators is already a well-demonstrated success, and to the use of distributing transformers in small sizes with low all-day efficiencies when the sub-stations, as arranged, provide a competent means for supplying the low-tension mains from station transformers or rotary converters and under such an arrangement as will assure the highest possible attainment in general and all-day efficiencies.

The present inflated condition of the copper market is a misfortune to the electrical industry and may do much toward disproving, in this instance, the accepted belief that money invested in copper is better than that invested in transformers; still there will be found many who will be unyielding in the contention that, under existing conditions, the increased costs of interest and attendance for low-tension distribution from large units in sub-stations direct, will be materially less than the costs attending operation under the plan adopted where the insidious losses of low all-day efficiencies find a convincing proof of their existence in the abnormal size of the consequential coal bills.

But these considerations are foreign to the point at issue: San Francisco is about to be released from its enthrallment at the hands of the soon-to-be-broken electric lighting and power monopoly; and certain it is that an era of unprecedented cheapness awaits the long-suffering electricity-consuming public of the metropolis of the West.

ON THE INEFFICIENCY OF ACETYLENE.

Many instances could be cited wherein the interests of legitimate corporations would be well subserved were they to enter into a vigorous campaign for educating the public in technical matters to such an extent as would enable it

---

*See *The Journal of Electricity*, Vol. VI, No. 5, pages 98-9, November, 1898.

to eventually discern fact from fiction. To do so is the province of all trade journals in their respective lines, and the manner in which the *Progressive Age*, a well known gas paper, has taken up the subject of the economy of acetylene gas as an illuminant in competition with city gas, is exemplary. From the beginning that publication has been pronounced in its support of acetylene as having its own niche in the problem of economy in the gas world, and in the pursuit of its investigations it is actuated by the desire to produce facts and only facts.

The extravagant statements in the catalogues of American acetylene generator manufacturers as to the efficiency of acetylene has led to a widespread illusion that in its use may be derived a method of illumination by gas that will enable each family, for instance, to produce the new gas for all purposes at considerably less expense than the cost of service from city mains. These catalogues are reproductions of each other very largely, and all contain comparative statements of the superiority and cheapness of acetylene over all other forms of lighting. Nine of them represented the cost of producing 100 candlepower-hours to vary from $2.27 to $7.50 for city gas, against from $1.09 to $2.40 for acetylene. The ratio of cost in the compilation varied from 1.0 to 4.2, with an average ot 2.6; or in other words, these nine catalogues made the contention that, in general, city gas is 2.6 times as expensive as acetylene for equal illumination. The gross error of these statements brands them as unpardonable misrepresentations.

The catalogues referred to assumed the use of 10, 15, 16, and 18 candlepower coal gas. Although 16-candlepower coal gas is common in England and France where very little little water gas is used, in the United States coal gas runs from 18 to 22 candlepower, and water gas from 22 to 30 candlepower per five cubic feet per hour. The assumption of 22-candle gas will be under rather than above the average. The candlepower of acetylene per five cubic feet consumption per hour is represented to be "250, 300, and even 400 candles," but conservative authorities place it at 240 candles. Further representations place the price for city gas to average $3.00 per thousand, while a thousand cubic feet of acetylene is declared to cost variously from $5.45 to $12.00. The fact is that the average price for city gas is nearer $1.50, while at the present prices acetylene will cost the consumer at least $13.33, although in the two cases of town lighting now in operation by acetylene in the United States, the price is $20.00 per thousand at the consumer's meter. The price of carbide in 100-pound drums, f. o. b. at Niagara, is 4½ cents per pound, to which the consumer must add the cost of transportation and the dealer's expense and profit. Tests at the acetylene exhibition held in London last summer showed that the best automatic generators delivered 4.5 cubic feet of acetylene gas per pound of carbide, from which is to be deducted say, six per cent. for leakage—which is low—leaving a production of 4.2 cubic feet per pound. This figure is for the best of the automatic type, but poorer classes of generators were found to yield as low as 3.5 cubic feet per pound. Consumers of carbide for this class of work will pay from five to 8 cents per pound for carbide, with an average price of 5.6 cents per pound, and these figures show the cost of producing acetylene to be $13.33 per thousand as stated.

On this basis, which represents actual conditions closely, the cost of illumination per 100-candlepower-hours is as follows:

City gas	$1.36
Acetylene	2.77
Ratio	0.05

Under average conditions, therefore, city gas costs about one-half as much as acetylene for equal illumination, and not 2.6 times as much as acetylene generator makers claim.

THE EDISON THREE-WIRE PATENT.

A subscriber asks for the date of expiration of the Edison three-wire patent, and also if it would be legally considered an infringement of said patent if three wires were used of equal area or gage; that is, if the neutral wire is the same in size as either outside wire.

The United States letters patent for the Edison three-wire system of electrical distribution is dated March 20, 1883, its number being 274,290. As it is a 17-year patent, it expires on March 20, 1900.

Any combination of circuits in which the neutral or "compensating conductor" is carried back to a division or neutral point in the sourse of energy, whether it be dynamos in series or a dynamo with a third brush, or primary or secondary batteries, or a transformer or transformers or otherwise, or whether it be a three or four or five wire system or more, is clearly covered by the patent specifications. Obviously, therefore, the use of three wires of equal cross section as described would constitute an infringement, so long as the neutral is by any manner carried back to the compensating point of the source of supply.

THE STORY OF THE THREE EGGS, IMPROVED.

One of the installation engineers of General Electric Company, who is particularly well known in the Pacific Northwest, and who, being of Norweigan descent, frequently becomes mixed in his "j's" and "y's," was asked in Portland recently if he had heard the story of the three eggs. Though the story referred to is an ancient chestnut, still he said he had not heard it.

"Two bad," exclaimed the other, with a twinkle.

The G. E. man looked serious a moment, and then came the dawning which found expression in his relaxing features and the sage observation:

"That's a good yoke!"

SIEMENS & HALSKE ALTERNATING MACHINERY.

If competition is the life of trade, activity in lines of transmission installation and general alternating current work will be materially increased in the near future by the accession of the Siemens & Halske Electric Company of America to the list of the large electrical manufacturing concerns producing that class of dynamo-electric machinery. Announcement is made by the Siemens & Halske company that within six months it will be prepared to deliver all classes of electrical machinery, and, in addition to the superior direct-current apparatus it is now manufacturing, especial attention will be given to the production of high-grade transformers, meters, and single, two and three phase generators of all capacities. It will, therefore, be a representative electrical manufacturing concern in all branches of the trade, and as such, it will be welcomed by all save its competitors.

PROFFESSOR FORBES MAKES A CORRECTION.

Prof. George Forbes has submitted the following self-explanatory communication relative to the paper read by himself before the Society of Arts, London, on the long distance transmission of electrical power:

> In a paper of mine (reprinted in abstract in the number of the *Journal of Electricity* for June, Vol. VII, page 97) some tables are given for facilitating calculations connected with the transmission of electrical energy to a distance. In Table III (page 99), the column of current densities, with an inefficiency of 1.3, is wrong, and as these columns may probably be copied, I desire to give the correct values of the current densities at the inefficiency 1.3 for the different distances and electric pressures indicated by the reference letters A to K. These are as follows:

A	1064	D	266	G	152
B	532	E	215	H	133
C	355	F	177	K	89

Personal

J. A. LIGHTHIPE, engineer of the Pacific Coast office of the General Electric Company, has been in the East for a month past that he might attend the annual gathering of the district engineers of the General Electric Company at Schenectady.

R. S. MASSON has resigned the electrical engineership of the San Francisco office of the Westinghouse Electric and Manufacturing Company, and has accepted the position of assistant general manager of the Independent Light and Power Co., San Francisco.

W. R. SUMMERHAYS, general manager of the Mutual Light and Power Company, San Francisco, is in the East presumably for the purpose of letting contracts for the installation of modern apparatus in the new station which the Mutual company is building.

E. W. SUTCLIFFE has retired from the position of electrical engineer of the Central California Electric Company, Sacramento, that he might accept a similar position with the Butte County Electric Power Company, the new power transmission being installed for Chico, Cal., and vicinity.

LOCALIZING FAULTS IN CONCENTRIC CABLES.

THE practice of burning out faults in underground conductors has the disadvantage of often obliterating all traces of the cause of the fault, and indeed it seems unnecessary to do so in view of the fact that faults may be accurately located and removed without burning out or reducing their resistance to less than about 1000 ohms. Two English methods of doing this are described by Hamilton Kilgour in a paper read before the Northern Society of Electrical Engineers.* Assume that a fault in a concentric cable is to be localized, in which event the testing set or bridge is connected as shown in Figure 1, wherein r is a known resistance, variable at will, and f is the fault to be localized.

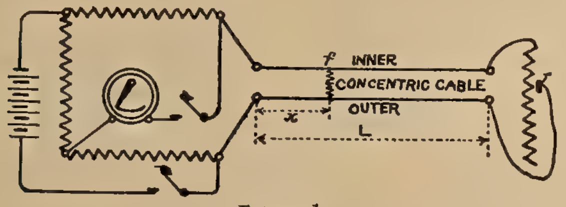


FIGURE 1.

If A = resistance of the fault plus the resistance of the inner and outer conductors up to the fault;
B = parallel resistance of the fault and circuit formed by the inner and outer conductors beyond the fault and the variable resistance, plus the resistance of the inner and outer up to the fault;
C = resistance of inner and outer of the whole length of the cable in series, which is assumed to be known in advance;
r = value of the variable resistance;
x = distance in yards to the fault as shown in the figure;
L = length of the cable in yards, as shown; then

$$x = \frac{B - \sqrt{[(A-B)\{(C+r)-B\}]}}{C} . L$$

and, after preliminary trial, it is not difficult to assign a value to r, which will give accurate results if care has been taken in making connections, allowing for testing the leads, etc.

Murray's loop test is, however, considered preferable to the above, inasmuch as it is unnecessary to attempt to determine the resistance of the fault. In it, either the inner or the outer conductor of the concentric cable (preferably the inner as it is the more likely to be intact) up to the fault forms one arm of the bridge as shown in Figure 2; the remaining part of the conductor and the return lead (which may be the inner or outer of another cable, or a special cable laid along the road surface for the purpose of the test) from the far end of the faulty cable forms the second arm; one set of the proportional coils and the variable bridge resistance form the other two arms of the bridge; whichever of the two conductors of the faulty cable that is not used as above described, is employed as the galvanometer lead to the junction of the two arms of the bridge at the fault, all as shown in Figure 2.

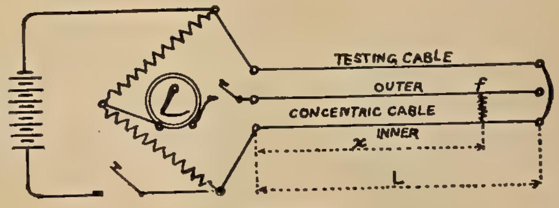


FIGURE 2.

If A = ratio of the resistance of the faulty cable conductor (used as one bridge arm) up to the fault to the resistance of the remainder of this conductor and of the return lead in series;
B = ratio of the resistance of the return lead to the resistance of the whole length of the conductor used as a part of the bridge;
L = length of the cable in yards;
x = distance in yards to the fault; then

$$x = \frac{A(1+B)}{1+A} . L$$

Or, if $A' = A$
$B' = 1/B$

$$x = \frac{A'(1+B')}{B'(1+A')} . L$$

It is stated that after localizing a fault by this method, it has occurred more than once on dissecting the fault that there has been found merely a single parted wire in the outer conductor, the solder being still visible, and a tiny pin hole through the inner insulation immediately below one of the free ends of the broken wire, the cable being otherwise quite uninjured.

The Electrician, Vol. XLIII, No. 6, June 2, 1899.

Gas

INDUSTRIAL GAS.—IV.

BY FRANK H. BATES.

THE HEMPLE APPARATUS. When it is desirable to make an accurate analysis of a gas mixture in the laboratory, and when time is not an important factor, the Hemple apparatus affords a means, and is, in consequence, very largely used.

Description. The simple gas burette, Figure 7, consists of two glass tubes, A and A′, which are connected by a thin rubber tube about 120 centimeters (about 47.24 inches) long. The ends of the tubing are simply closed over a projecting glass tip from each burette, and made fast by wrapping tightly with string. To facilitate the cleaning of the burette, the rubber tube is divided in the middle and the two ends, R R′, joined together by a piece of glass tubing. Inside the feet, the tubes A and A′ are bent at right angles and conically drawn out. They resemble, in general construction, the tubes described in the first number of these articles. The tube A is calibrated so as to contain exactly 100 cubic centimeters between the upper extremity and the lowest graduation, and is drawn out at the end to a thick walled tube *m*, while the tube A′ is widened at the end to a mouth *h* for the reception of liquids. The tube A, or measuring burette as it is termed, is supplied with or without glass stop-cocks. A piece of rubber tubing over the end *m* may be closed in a completely satisfactory manner by a Mohr pinch-cock, *f*, which is put on close to the end of the capillary. Hemple states that he found it much easier to make tight rubber tops and connections than perfectly tight glass stop-cocks, wholly aside from the fact that by giving up the glass cock the apparatus is rendered less fragile and less costly. The writer prefers the glass cocks however, and has found that no trouble need be experienced in their use when they are kept well lubricated, as heretofore directed. If pinch-cocks are used they must be removed from the rubber tubing after using, and in the use of either pinch-cocks or glass stop-cocks occasional tests must be made to make certain that no leakage is possible. Notwithstanding the fact that readings cannot be made under the rubber tube, and that the pinch-cock cannot always be put on above the tube in exactly the same position, no error results therefrom, since the glass tube is very small. Hemple found that differences in volume are much less than one-tenth of a cubic centimeter, a variation which, in determinations not made over mercury, may be entirely disregarded.

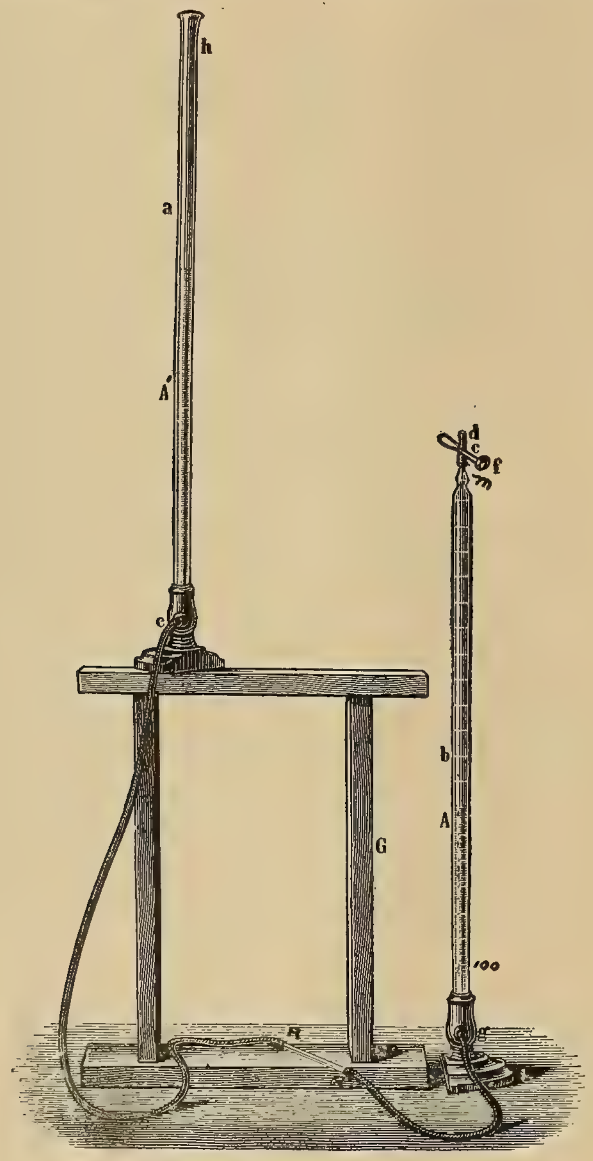
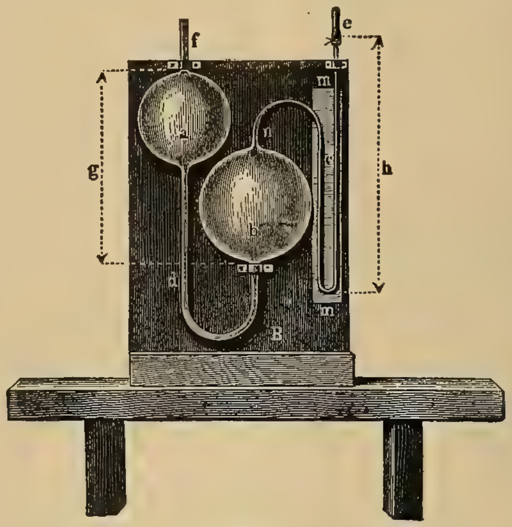


FIGURE 7.



FIGRUE 8.

The graduations on the measuring burette A are divided into fifths of cubic centimeters, and the numbers run both up and down.

Operation. To briefly review the method of operation: Fill the tubes A′ and A with water which has been saturated with the gas to be examined, taking care to drive all air from the connecting rubber tube, by suitably raising or lowering the tubes; then join the burette A to the vessel containing the gas by means of a glass or rubber tube filled with water. This tube is readily filled by simply raising the level-tube A′. To fill the burette with the gas to be examined, grasp the tube A′ in the left hand, close the rubber tube at *e* by pressing it between the little finger and palm of the left hand, and pour out the water in A′. Place the level-tube A′ on the floor, and open the pinch-cock *f* on burette A. The water will now flow into the level-tube A′ and draw the gas into the burette A. As soon as A is filled with gas, close the pinch-cock *f*, disconnect A from the gas holder, and after waiting three minutes for the liquid to drain down the walls of the burette, take up the level-tube A′ by the iron feet, and by raising and lowering bring the water in both tubes to the same level. The gas is now under atmospheric pressure, and its volume is read off. To measure off exactly 100 cubic centimeters, bring somewhat more than 100 cubic centimeters of the gas into the burette, close the latter with the pinch-cock (or glass stop-cock), and let the water drain down for a period of three minutes. Now compress the gas to less than 100 cubic centimeters by raising the level-tube; close the rubber tube at *g* with the thumb and first finger of the left hand, set the level-tube on the table, and, raising the burette A with the right hand to the level of the eyes, carefully open the rubber tube (held closed by the left hand), and let the water run back until the meniscus stands at the 100-cubic centimeter mark, when close rubber tube again and open the pinch-cock *f* for a moment, when the excess of gas will escape and there remains in the burette exactly 100 cubic centimeters of the gas under atmospheric pressure. The above directions illustrate Hemple's method for obtaining a sample of exactly 100 cubic centimeters; the writer however, would suggest the method described in the first number of these articles in connection with the makeshift apparatus, by which a little more than 100 cubic centimeters of gas is drawn into the burette, then compressed to exactly 100 cubic centimeters, when the excess pressure is relieved by opening the stop-cock or pinch-cock for a moment, thereby giving just 100 cubic centimeters under atmospheric pressure.

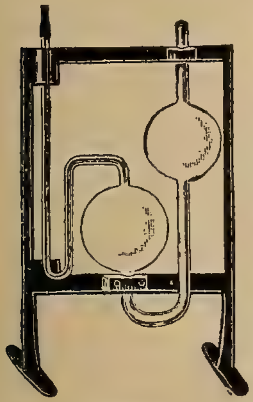


FIGURE 9.

The Hemple apparatus provides a special pipette for each reagent, so designed as to make the absorptions rapid and thorough and yet protect the reagents from dilution or weakening by the absorption of air. As each pipette (the vessel used to contain the reagent) is in turn connected to the gas burette, the following description of the various pipettes will serve to familiarize the reader with their general operation.

The simple absorption pipette, Figure 8, consists of two large bulbs, *b* and *a*, joined by the tube *d*, and of a thick-walled glass tube, *n c*, of one-half to one millimeter internal diameter, and bent as shown in the figure. This tube will be termed the capillary tube. The bulb *a* holds about 100 cubic centimeters and *b* about 150 cubic centimeters, so that when 100 cubic centimeters of gas is brought into *b*, sufficient space for the absorbing liquid will remain. To protect the pipette from being broken and to facilitate its manipulation, it is screwed to a wooden or iron standard. Figures 8 and 9 show the wooden and iron supports respectively. On account of the different behavior of wood or iron and glass toward changes of temperature and atmospheric moisture, it is advisable to fasten the glass at only three places by means of metal bands and sealing wax, the capillary tube being allowed to project from two to three centimeters above the frame. A short piece of rubber tubing is wired on to the free end of the capillary. The distance *h* (Figure 8) must be greater than *g*, so that it may be possible to enclose a gas between two columns of liquid in the pipette.

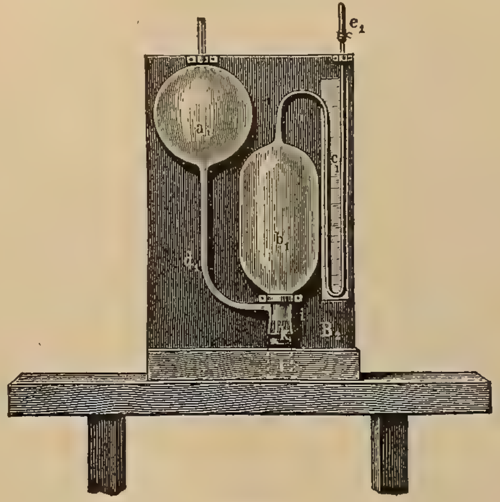


FIGURE 10.

The simple absorption pipette for solid and liquid reagents. The only difference between this and the simple pipette is that in place of the bulb *b* (Figure 8), there is inserted the cylindrical part b_1 (Figure 10), which can be filled with solid substances through the neck *i*. A cork or rubber stopper *k*, held in place by a wire, closes the neck. A glass tube (Figure 11) closed at the top, and over which a rubber ring, cut from a rubber tube is drawn, makes an excellent stopper. By this arrangement only a narrow strip of rubber is exposed to the action of the reagent. See Figure 11.

The double absorption pipette. Reagents which are acted upon by oxygen — potassium pyrogallate, cuprous chloride, ferrous salts, etc. — cannot be kept in the aforementioned pipettes, since the reagent would, in a short time, become inactive through contact with air. The double pipette overcomes this difficulty, permitting the use of the reagents under an easily movable atmosphere which is free from oxygen, and the reagent employed may be kept completely saturated with those constituents of the

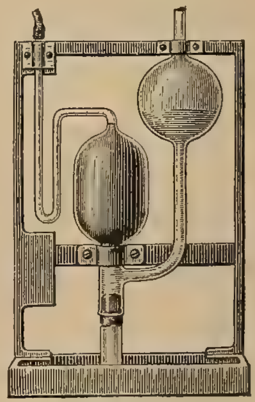


FIGURE 11.

gas that it does not strongly absorb, this being a great advantage. The pipette consists of the large glass bulb *a* (Figure 12), of about 150 cubic centimeters capacity, and three smaller bulbs, *b*, *c* and *d*, each containing only 100 cubic centimeters. They are connected by the bent tubes *e*, *f* and *g*, and end in the bent capillary tube *k*.

The double absorption pipette for solid and liquid reagents. The construction may be easily understood from Figure 13, and what has already been said in reference to the simple pipette for solid and liquid reagents.

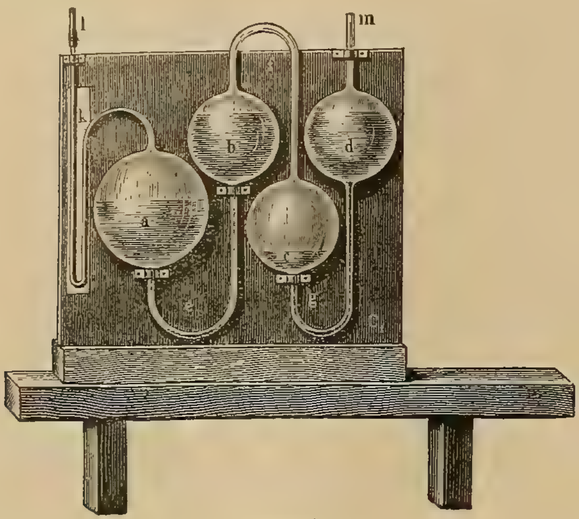


FIGURE 12.

To prepare the double pipettes for use, introduce the solid substance to be employed, if any, and then fill the pipette completely with the gas to be analyzed by slowly drawing the gas through. Now pour water through *m* into the bulb *d* until *g* is full. Close the rubber tube *l* with a pinch-cock, insert into it a thin glass tube at least one meter long, and fasten a funnel to the upper end of the latter by means of a piece of rubber tubing. Upon pouring the reagent into the funnel, the pressure due to the height of the column enables it to quickly pass through the capillary tube *k* into the bulb or cylinder *a*. The action may be hastened by gentle suction at *m*. After about 100 cubic centimeters of the reagent has been introduced, the bulb *d* is nearly filled with water and the gas remaining in *a* is driven out through the long tube by blowing into *m*. The pipette is now closed at *l* and shaken for some time to remove from the bulb *b* the gases absorbable by the reagent. After driving out any gas bubbles which may be in *a*, suction is applied at *m* and so much gas is sucked out of the bulb *b* that the liquid in *d* will enter and fill *c*. If the water first poured in is not sufficient, more must be added from time to time.

In pipettes thus prepared the tubes *k* and *e* and the bulb *a* are filled with the aborbent, the space from *b* to *f* with a gas free from oxygen, *c* and *g* with water, and *d* with air. While the reagent in the simple pipette may be considered to be saturated with gas only when it is kept in continual use, that in the double pipette on the contrary, remains saturated for an exceptionally long time, since the diffusion must take place through the confining 100 cubic centimeters of water and through the narrow tube. The error caused by this theoretical possibility may be wholly disregarded in using the pipette. It is possible to fill the compound pipette without the aid of the long tube by manipulating so as to gradually cause the reagent to enter and then the water. When a new filling of the pipette is necessary, the reagent may easily be drawn out by means of a rubber pump.

The ethylene pipette. This is a special pipette devised for use with sulphuric acid (fuming) or bromine in the absorption of ethylene and the heavy hydrocarbons or fixed illuminants. It consists of a simple pipette, having three bulbs (Figure 14), the small bulb being filled with glass beads, which afford a large absorbing surface as with the Orsat apparatus, in which glass tubes were used. With the use of sulphuric acid, it is advisable to use only that which is sufficiently concentrated, to crystallize on a slight lowering of temperature. The absorbing power of acid of this strength is 8.

One passage of the gas into the pipette is usually sufficient to effect the complete absorption of the ethylene and heavy hydrocarbons. In this reaction some sulphur dioxide (SO_2) is usually formed, and, moreover, the vapor of fuming sulphuric acid has a very high tension, so that the gas residue before being measured, must be freed from the acid vapors in the caustic potash pipette, a single passage of the gas into the pipette sufficing. To avoid having the rubber connections between the pipette and the burette attacked by the fuming sulphuric acid, the apparatus is so put together that the sulphuric acid does not quite fill the capillary of the pipette, and the connecting capillary is allowed to remain empty; the short rubber tube of the burette is also freed from liquid by means of a narrow-tipped suction pipette, any reagent remaining in the tube being first washed out with with the same pipette. If care is taken that the sulphuric acid is stopped after the absorption at the same point in the capillary at which it stood when the burette and pipette were first put together, then the small volume of air contained in the capillary tubes in the beginning causes no error in the de-

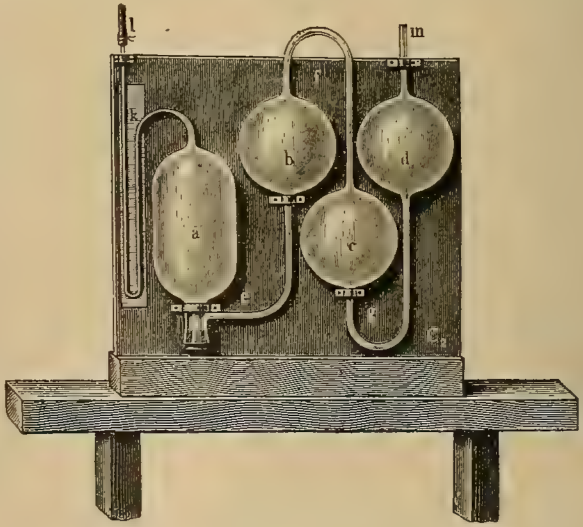


FIGURE 13.

termination of the heavy hydrocarbons or other gases, with the exception of nitrogen. In the nitrogen determination, allowance may be made for this air volume, but as each centimeter of the empty capillary corresponds to only 0.008 cubic centimeters, this value falls below the limit of unavoidable errors. After the absorption, the rubber tube is taken off from the pipette, and the capillary and larger tube are made air-tight by closing with little glass caps, which are pushed over narrow Mohr rings placed upon the tube.

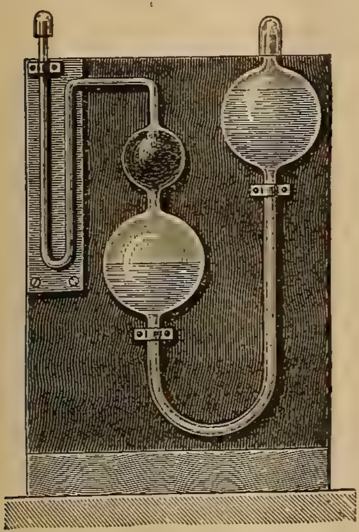


FIGURE 14.

For most purposes the bromine absorption is sufficiently accurate and far more convenient. It is also used in the pipette just described. It is not necessary to fill the pipette completely with it, being quite sufficient if a few cubic centimeters of bromine lie under water in the pipette. The bromine always remains below, there being a distinct separation of the bromine and water by reason of greater specific gravity. The water above will, however, be saturated with bromine vapor which absorbs the ethylene, etc. After this absorption, as in the case with the sulphuric acid, and as already explained in connection with the Elliott apparatus, the gas must be freed of the bromine vapor by passing it into the potassium hydroxide pipette.

(The writer is largely indebted to the work on "Methods of Gas Analysis," by Dr. W. Hemple, translated by L. H. Dennis, for the descriptions and illustrations of the Hemple apparatus.)

(Continuation in next number.)

Transmission

ALUMINUM FOR ELECTRICAL CONDUCTORS.

ALUMINUM has, for the last two or three years, been used for electrical conductors in such continually increasing amounts and with such successful results, and the desire for explicit information concerning its physical and mechanical qualities is so universal, especially in electrical transmission circles, that it has been determined to present in the following article such facts in regard to aluminum as need be known when considering its use for electrical conductors.

In comparing copper and aluminum, the following facts regarding the two metals should first be noted:

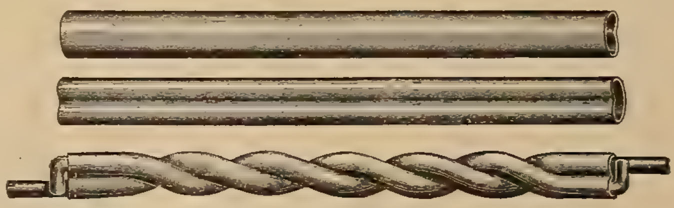
	Aluminum.	Copper.
Specific Gravity - - - - - -	2.68	8.93
Relative Specific Gravity - - -	1.00	3.33
Conductivity - - - - - - - -	54 to 63	96 to 99

Tensile Strength per square inch, Aluminum, 24,000 to 55,000 lbs.
" " " " Copper 30,000 to 65,000 lbs.

The different grades and consequent different mechanical and electrical characteristics of both aluminum and copper make it impossible to give absolute ratios between the two metals of weight, tensile strength, price, etc., for cross-sections of equal conductivity. Unless specially mentioned, however, in this article, a conductivity of 61 for aluminum and 97 for copper will be assumed.

On account of the lower conductivity of aluminum, the cross-sections of aluminum and copper wire or bars of same resistance and same conductivity will be in the inverse ratio of their conductivities (97 : 61 :: 159 : 100); thus an aluminum wire of 159,000 circular mils area will have the same resistance as a copper wire of 100,000 circular mils area. This ratio is approximately the same as that between wires separated by one number in the Brown & Sharp gage. Thus, No. 1 aluminum wire is equivatent to No. 3 copper; No. 2 is equivalent to No. 4 copper, etc.

The comparative weights of equal volumes of aluminum and copper are as 1 for aluminum and 3.33 for copper. Therefore the relative weights of given lengths of same conductivity will be as 47.77 for aluminum to 100 for copper (159 × 1 : 100 × 3.33 :: 47.77 : 100); or, differently stated, the weight per mile or per thousand feet of aluminum wire is 47.77 per cent. of the weight of the same length of copper of same conductivity.


THE ALUMINUM SLEEVE-JOINT.

Inasmuch as it is necessary to use a larger cross-section of aluminum in order to obtain equal conductivity with copper, it is also necessary to take this increased size into consideration in determining the relative breaking loads. A load which would break a copper wire of 100,000 circular mils area would not break an aluminum wire of 159,000 circular mils area, even though the aluminum might be relatively weaker than the copper for equal sections. In order to obtain relative breaking loads, the tensile strength per square inch of aluminum should be multiplied by 159 and compared with the tensile strength per square inch of copper. Thus with an aluminum and copper wire of same conductivity, but the copper wire having a tensile strength of 50,000 pounds per square inch, and the aluminum wire only 31,446 pounds per square inch, the same actual load would be required to break either wire. (31,446 × 159 = 50,000.)

The question of price of aluminum or copper is practically a question not of price per pound but price per mile or of any given length. The weight per mile of aluminum is 47.77 per cent. of the weight of copper of same length and of same conductivity. Thus aluminum conductors will cost the same per mile as copper of equal conductivity if the price per pound of the copper is 47.77 per cent. of the price per pound for the aluminum. Take, for example, copper at 20 cents per pound and aluminum at 41.87 cents per pound. The cost per mile for wire of same conductivity

FACTORS FOR THE DIFFERENT CONDUCTIVITIES OF ALUMINUM.

CONDUCTIVITY OF ALUMINUM.	63	62	61	60	59	58	57	56	55	54
Relative cross-section. . . . . (Copper equal 100)	154.	156 5	159.	161.7	164.4	167.3	170.2	173.2	176.3	179.7
Weight of aluminum. (weight of copper of equal length and equal resistance equal 100.)	46 25	47.	47.77	48.55	49.38	50.24	51.11	52.02	52.97	53.95
Tensile Strength—Factor by which to multiply tensile strength per square inch of aluminum to obtain tensile strength per square inch required in a copper wire of equal resistance in order to secure same breaking strength.	154.	156 5	159.	161.7	164.4	167.3	170.2	173.2	176.3	179.7
Price—Factor by which to multiply copper price per pound to obtain equivalent price of aluminum; also factor by which to divide aluminum price per pound to obtain equivalent price of copper	2.16	2.13	2.1	2.06	2.03	1.99	1.96	1.92	1.89	1.8
Price—Factor by which to divide copper price per pound to obtain equivalent price of aluminum, also factor by which to multiply aluminum price to obtain equivalent price of copper	.4625	.47	.4777	.4855	.4938	.5024	.5111	.5202	.5297	.5395

TABLE I.

in either metal will be the same. (100 pounds of copper at 20 cents = $20.00; 47.77 pounds of aluminum at 41.87 cents = $20.00.)

Reduced to the form of rules, the calculations are as follows:

To obtain the aluminum price corresponding to a known copper price, divide the cost of copper per pound by .4777, or multiply by 2.1.

To obtain the copper price corresponding to a known aluminum price, multiply the cost of aluminum per pound by .4777, or divide by 2.1.

In case aluminum of conductivity other than 61 is used, the factors (.4777, 2.1 and 159) as obtained above would be somewhat changed. In Table I are given the factors for the different conductivities of aluminum as compared with 97-conductivity copper of the same resistance.

COMPARATIVE WEIGHT AND STRENGTH OF ALUMINUM AND COPPER TELEPHONE WIRE OF EQUAL CONDUCTIVITY.

GRADE A75 ALUMINUM WIRE, CONDUCTIVITY 58 IN THE MATTHIESSEN SCALE.

	COPPER.	ALUMINUM.
Comparative section of equal conductivity,	100	167
Comparative weight of given lengths of equal conductivity,	100	50.2

COPPER.			ALUMINUM.	COPPER.	ALUMINUM.	ALUMINUM.	
No.	Gauge.	Diameter Inches.	Diameter Inches.	Weight per Mile.	Weight per Mile.	Tensile Strength per Square Inch.	Tensile Strength comparative to Copper of equal Conductivity.
16	B. W. G.	.0650	.0841	68.	33.	42,000	70,140
14	B. I. S.	.0800	.1035	102.	51.6	40,000	66,800
12	B. & S.	.0808	.1045	104.7	52.6	40,000	66,800
13	B. I. S.	.0920	.1190	135.	68.	38,000	63,460
10	B. & S.	.1019	.1318	162.3	83.6	36,000	60,000
12	B. I. S.	.1040	.1345	173.	87.1	36,000	60,000
10	B. I. S.	.1280	.1655	262.	132.	35,000	58,450
8	B. & S.	.1285	.1662	264.8	133.	35,000	58,450
10	B. W. G.	.1340	.1733	287.	144.5	34,000	58,780
8	B. W. G.	.1650	.2134	435.	219.	33,000	55,000

TABLE II.

The stiffness and tensile strength of commercially pure aluminum (95.50 per cent.) is less than that of aluminum which has been alloyed with a small percentage of another metal. Thus a No. 12 B. & S. gage wire of pure aluminum will have a tensile strength of about 39,000 pounds per square inch; whereas, if alloyed with one per cent. of foreign metal, the tensile strength per square inch would be about 45,000 pounds; or, if alloyed with two per cent. of foreign metal the tensile strength would be increased to about 55,000 pounds. In sections larger than No. 12, which necessarily have had less work put upon them in rolling and drawing, the tensile strengths are not so high, but the same proportionate increases in strength are obtained by alloying. On the other hand, the conductivity of aluminum is reduced by alloying. Commercially pure aluminum has a conductivity of 63 per cent. in the Mattheissen Standard Scale. This conductivity is reduced to about 58 in a one per cent. alloy, and to about 54 in a two per cent. alloy. It is advisable, therefore, to determine just what are the requirements of each case as to conductivity and tensile strength, and to use the exact grade which will, with the minimum cross-section and consequent minimum weight, fulfill the electrical and mechanical requirements. It will be understood that it is not necessary to adhere to one or two per cent. alloys; intermediate alloys, such as three-quarters per cent., or one and one-half per cent. are made whenever required and quite as frequently as the one and two per cent. alloys.

RESISTANCE AND TENSILE STRENGTH OF ALUMINUM TELEPHONE WIRE.

Grade.	Conductivity.	Comparative section of equal Conductivity. Copper at 100.	Comparative weight of given lengths of equal Conductivity, Copper at 100.
AO.	62%	156.4	47.
A75	58	167.	50.2
A2.	54	180.	54.

Number in B. & S. Gauge	Diameter in Mils	GRADE AO.		GRADE A75.		GRADE A2.	
		Res. per 1,000 ft. at 75° F.	Tensile Strength.	Res. per 1,000 ft. at 75° F.	Tensile Strength.	Res. per 1,000 ft. at 75° F.	Tensile Strength.
4	204.31	.4012	27,000	.4288	33,000	.4605	40,000
5	181.94	.5058	27,500	.5408	34,000	.5818	42,000
6	162 02	.6380	28,000	.6820	35,000	.7325	44,000
7	144.28	.8044	29,000	.8600	36,000	.9235	46,000
8	128 49	1.034	30,000	1.105	37,000	1.187	48,000
9	114.43	1.278	32,000	1.367	39,000	1.468	50,000
10	101.89	1.613	33,000	1.724	40,000	1.852	51,000
11	90.74	2.033	35,000	2.173	41,000	2.335	53,000
12	80.81	2.565	39,000	2.741	42,000	3.084	55,000

TABLE III.

When aluminum is used for 'bus-bars in station work, or for main circuits in electrolytic plants using large currents, the question of tensile strength does not need to be considered, for the sections used are so large that ample strength is obtained. For these purposes, therefore, aluminum of 63 per cent. conductivity can be employed, the weight of which as compared with copper of same conductivity is 46.25 per cent.

Rolled or drawn bars can be supplied in any required section and of reasonable length. Bars of approximate size of 1 × 6 inches can be rolled in lengths of about 14 feet. Bars of approximately ½ × 4 inches can be rolled in lengths of about 26 feet, and smaller bars can be made somewhat longer. For switchboard and station work, drawn bars with smooth edges and round corners are made. In the larger sizes, however, sawed or sheared edges are generally used, as drawing of these large sizes entails some additional expense.

Table of Dimensions and Weights of Aluminum and Copper Wire.

Specific Gravity of Aluminum taken as 2.68, water weighing 62.355 pounds per cubic foot. Specific Gravity of Copper, 8.93.

Am. Gauge, B. & S. No.	Diam. Mils.	AREA.		WEIGHT AND LENGTH.			
		Circular Mils. (d^2) 1 mil. = .001 inch.	Square Inch. (d^2 x .7854.)	Pounds per mile, Alum'n.	Pounds per mile, Copper.	Feet per Pound Aluminum.	Feet per pound Copper.
0000	460.000	211600.00	166190.	1018.30	3393.07	5.183	1.728
000	409.640	167805.00	131790.	807.52	2690.75	6.539	2.179
00	364.800	133079.40	104520.	640.36	2133.74	8.246	2.748
0	324.860	105534.00	82886.	507.83	1692.14	10.397	3.465
1	289.300	83694.20	65733.	402.81	1342.21	13.108	4.368
2	257.630	66373.00	52130.	319.44	1064.39	16.529	5.508
3	229.420	52634.00	41339.	253.28	843.96	20.846	6.946
4	204.310	41742.00	32784.	200.90	669.44	26.281	8.757
5	181.940	33102.00	25998.	159.30	530.79	33.146	11.044
6	162.020	26250.50	20617.	126.35	421.02	41.789	13.924
7	144.280	20816.00	16349.	100.21	333.93	52.687	17.556
8	128.490	16509.00	12966.	79.46	264.78	66.445	22.140
9	114.430	13094.00	10284.	62.99	209.90	83.822	27.931
10	101.890	10381.00	8153.2	48.71	162.32	105.68	35.215
11	90.742	8234.00	6467.0	39.63	132.04	133.24	44.398
12	80.808	6529.90	5128.6	31.43	104.71	168.01	55.983
13	71.961	5178.40	4067.1	24.83	83.02	211.86	70.595
14	64.084	4106.80	3146.9	19.76	65.83	267.17	89.022
15	57.068	3256.70	2557.8	15.67	52.22	336.93	112.27
16	50.820	2582.90	2028.6	12.43	41.42	424.81	141.55
17	45.257	2048.20	1608.6	9.857	32.85	535.62	178.47
18	40.303	1624.30	1275.7	7.814	26.04	675.67	225.14
19	35.890	1288.10	1011.66	6.199	20.65	851.79	283.82
20	31.961	1021.50	802.28	4.916	16.38	1074.11	357.91
21	28.462	810.10	636.25	3.898	12.99	1354.65	451.38
22	25.347	642.70	504.78	3.091	10.30	1707.94	569.10
23	22.571	509.45	400.12	2.451	8.169	2153.78	717.66
24	20.100	404.01	317.31	1.944	6.478	2715.91	904.97
25	17.900	320.40	251.64	1.542	5.138	3424.66	1141.1
26	15.940	254.01	199.50	1.223	4.075	4317.78	1438.7
27	14.195	201.50	158.26	.9694	3.230	5446.63	1814.9
28	12.641	159.79	125.50	.7688	2.562	6868.13	2288.5
29	11.257	126.72	99.526	.6098	2.032	8698.03	2884.9
30	10.025	100.50	78.933	.4836	1.612	10917.0	3637.7
31	8.928	79.71	62.604	.3836	1.278	13762.8	4585.9
32	7.950	63.20	49.637	.3041	1.013	17361.1	5784.9
33	7.080	50.13	39.372	.2412	.8039	21886.7	7292.9
34	6.304	39.74	31.212	.1912	.6373	27609.1	9199.6
35	5.614	31.52	24.756	.1517	.5055	34807.3	11627.4
36	5.000	25.00	19.635	.1203	.4010	43878.9	14620.6
37	4.453	19.83	15.567	.0954	.3179	55340.4	18440.0
38	3.965	15.72	12.347	.0757	.2521	69783.7	23252.6
39	3.531	12.47	9.7939	.0600	.1999	88028.2	29331.9
40	3.144	9.89	7.7676	.0475	.1584	111099.0	37019.2

TABLE IV.

In long distance transmission work, both good conductivity and good tensile strength are required. It is not recommended to use aluminum wire of less than 59 per cent. conductivity. If lower conductivity is used, a large wire is necessary to get a low resistance. Besides the increased cost entailed by the use of large wire, frequently the wire is of so great a diameter as to be cumbersome.

The following is an average specification for N. 2 B. & S. wire for long distance transmission work; wire to have a conductivity of 59 per cent.:

The weight is not to exceed 320 pounds per mile.

Conductivity of wire is not to be less than 59 in Mattheissen Standard Scale, and is thus to have a resistance at 15.5 degrees Centigrade not greater than .2443 ohms per thousand feet.

The tensile strength of wire is not to be less than 29,000 pounds per square inch, and the elastic limit not less than 14,000 pounds per square inch.

The elongation of the tension test pieces by breaking is to be not less than 10 per cent. in two inches.

Weight of Aluminum, Wro't Iron, Steel, Copper and Brass Wire.

DIAMETERS DETERMINED BY AMERICAN (BROWN & SHARPE) GAUGE.

Water at 62° Fahrenheit, 62.355 lbs. per cubic foot.

Drawn Wrought Iron is 2.8724 times heavier than Drawn Aluminum.
" Steel " 2.9322 " " " " "
" Copper " 3.3321 " " " " "
" Brass " 3.1900 " " " " "

No. of Gauge.	Size of each No.	Ft. per lb. Aluminum.	WEIGHT OF WIRE PER 1000 LINEAL FT.				
			ALUMINUM.	WR'T IRON.	STEEL.	COPPER.	BRASS.
	Inch.	*Feet.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
0000	.46000	5.185	192.86	553.97	565.50	642.68	615.21
000	.40964	6.539	152.94	439.33	448.45	509.32	487.92
00	.36480	8.246	121.28	348.40	355.65	404.20	386.94
0	.32486	10.396	96.18	276.30	282.02	320.50	306.83
1	.28930	13.108	76.29	219.11	223.68	254.20	243.35
2	.25763	16.529	60.50	173.78	177.38	201.60	192.98
3	.22942	20.846	47.97	137.80	140.67	159.86	153.02
4	.20431	26.281	38.05	109.28	111.57	126.78	121.37
5	.18194	33.146	30.17	86.68	88.46	100.54	96.26
6	.16202	41.789	23.93	68.73	70.15	79.72	76.32
7	.14428	52.687	18.98	54.43	55.56	63.23	60.53
8	.12849	66.445	15.05	43.23	44.12	50.14	48.00
9	.11443	83.822	11.93	34.28	34.99	39.77	38.07
10	.10189	105.68	9.462	27.18	27.74	31.53	30.18
11	.090742	133.24	7.505	21.56	22.01	25.01	23.94
12	.080808	163.01	5.952	17.10	17.46	19.83	18.99
13	.071961	211.86	4.720	13.56	13.84	15.73	15.06
14	.064084	267.17	3.743	10.75	10.98	12.47	11.94
15	.057068	336.93	2.968	8.526	8.704	9.890	9.468
16	.050820	424.81	2.354	6.761	6.903	7.843	7.508
17	.045257	535.62	1.867	5.362	5.474	6.220	5.955
18	.040303	675.67	1.480	4.252	4.342	4.933	4.723
19	.035890	851.79	1.174	3.372	3.443	3.912	3.755
20	.031961	1074.11	.9310	2.672	2.730	3.102	2.970
21	.028462	1354.65	.7382	2.121	2.165	2.460	2.355
22	.025347	1707.94	.5855	1.682	1.717	1.951	1.868
23	.022571	2153.78	.4643	1.333	1.361	1.547	1.481
24	.020100	2715.91	.3682	1.058	1.080	1.227	1.175
25	.017900	3424.66	.2920	.8388	.8563	.9731	.9316
26	.015940	4317.78	.2316	.6652	.6791	.7716	.7387
27	.014195	5446.63	.1836	.5276	.5385	.6120	.5858
28	.012641	6868.13	.1456	.4183	.4270	.4853	.4645
29	.011257	8698.03	.1155	.3317	.3386	.3849	.3683
30	.010025	10917.0	.0916	.2631	.2686	.3052	.2922
31	.008928	13762.8	.0727	.2087	.2130	.2421	.2318
32	.007950	17361.1	.0576	.1655	.1693	.1919	.1837
33	.007080	21886.7	.0457	.1312	.1340	.1522	.1457
34	.006304	27609.1	.0362	.1040	.1062	.1207	.1155
35	.005614	34807.3	.0287	.0825	.0842	.0957	.0916
36	.005000	43878.9	.0228	.0655	.0668	.0759	.0727
37	.004453	55340.4	.0181	.0519	.0530	.0602	.0577
38	.003965	69783.7	.0143	.0413	.0420	.0478	.0457
39	.003531	88028.2	.0114	.0326	.0333	.0379	.0363
40	.003144	111099.0	.0090	.0259	.0264	.0300	.0287
Specific Gravity Wire..............			2.680	7.698	7.858	8.930	8.549
Weight per cubic foot, Wire ...			167.111	480.000	490.000	556.830	533.073

TABLE V.

Wrapping test: Wire shall be capable of being wrapped in six turns around its own diameter, unwrapped, and again wrapped in six turns around its own diameter in the same direction as the first wrapping, without showing any cracks.

The wire is to be packed in coils 18 to 24 inches internal diameter. No joints will be permitted in any coil. Coils must not weigh less than 80 pounds each. Each coil must be securely tied with aluminum wire protected by burlap writing.

In case a No. 2 wire of 62 conductivity were wanted, the specifications as given above would be changed in the following points:

Conductivity of the wire is not to be less than 62 in Mattheissen Standard Scale and is thus to have a resistance at 15.5 degrees Centigrade, not greater than .2443 ohms per thousand feet.

The tensile strength of wire is not to be less than 23,000 pounds per square inch and the elastic limit not less than 11,000 pounds per square inch.

The elongation of the tension test pieces by breaking is to be not less than nine per cent. in two inches.

On account of the small sizes of wire used for telephone and telegraph purposes the breaking of the wire is to be specially guarded against in some instances. In such cases a wire of a slightly reduced conductivity but high tensile strength is used, the low conductivity being in most cases not objectionable, inasmuch as the conductivity is not so materially reduced as to interfere with the successful working of the wire.

For telephone and telegraph wires, the Pittsburg Reduction Company makes three grades: AO, A75 and A2, and in Table II is given the characteristics of grade A75 of these three grades, while Table III gives the resistance and tensile strength of the three grades of telephone wires.

The soldering of solid wire is not recommended. Small wires can be joined by twisting the ends around each other as is usually done in telephone and telegraph work. Aluminum sleeve joints either of tubes or rolled up sheet can be obtained from manufacturers who make such joints in copper for joining copper wire. For large sizes of aluminum wire where twisting the ends together is impossible, these mechanical joints give a strong and satisfactory connection. Joints of this kind are easily and quickly made; they possess mechanical strength equal to that of the wire itself, and the conductivity is equal to that of an equal length of the wire. The extended area of the contact surfaces, the force by which the surfaces are held together, and their protection from corrosion insure a permanent joint. Cables are best joined by soldering the ends in a brass or aluminum sleeve the same as is done with copper cables.

Cables of any size required are now on the market, and concentric laid cables up to a total of 127 wires, and 7 × 7 cables are made. Aluminum cables are used for street railway feeders and for all other places where copper cables have been heretofore used. It is seldom that so small a cable is used that the tensile strength of pure aluminum is not sufficient. Usually, therefore, cables are made of 63 or 62 conductivity wire, although if required, the the stronger grade wire can be used. Wire and cables with weatherproof insulation are also regularly supplied, and if required, arrangements can be made for covering aluminum wire with any other variety of insulation. Reference may be made to Tables VIII and IX for weights of these insulated wires and cables.

TABLE OF RESISTANCES OF PURE COPPER WIRE.*

Am. Gauge, B. & S. No.	RESISTANCE AT 75° F.				Log d^2.	Log *R*.
	R. Ohms per 1000 Feet.	Ohms per mile.	Feet per Ohm.	Ohms per lb.		
0000	.04906	.25903	20383.	.000076736	5.3255157	$\bar{2}$.6907235
000	.06186	.32664	16165.	.00012039	5.2248000	$\bar{2}$.7914392
00	.07801	.41187	12820.	.00019423	5.1241128	$\bar{2}$.8921264
0	.09831	.51909	10409.	.00030772	5.0236310	$\bar{2}$.9926082
1	.12404	.65490	8062.3	.00048994	4.9226953	$\bar{1}$.0935439
2	.15640	.82582	6393.7	.00078045	4.8219914	$\bar{1}$.1942478
3	.19723	1.0414	5070.2	.0012406	4.7212664	$\bar{1}$.2949728
4	.24869	1.3131	4021.0	.0019721	4.6205733	$\bar{1}$.3956659
5	.31361	1.6558	3188.0	.0031361	4.5198542	$\bar{1}$.4963850
6	.39546	2.0881	2528.7	.0049868	4.4191300	$\bar{1}$.5971092
7	.49871	2.6331	2005.2	.0079294	4.3183973	$\bar{1}$.6978419
8	.62881	3.3201	1590.3	.012608	4.2177208	$\bar{1}$.7985184
9	.79281	4.1860	1261.3	.020042	4.1170723	$\bar{1}$.8991669
10	1.	5.2800	1000.0	031380	4.0162392	0.0000000
11	1.2607	6.6568	793.18	.050682	3.9156109	0.1006283
12	1.5898	8.3940	629.02	.080585	3.8149065	0.2013327
13	2.0047	10.585	498.83	.12841	3.7141956	0.3020436
14	2.5908	13.680	385.97	.20880	3.6135004	0.4134415
15	3.1150	16.477	321.02	.31658	3.5127778	0.4934614
16	4.0191	21.221	248.81	.51501	3.4121076	0.6041316
17	5.0683	26.761	197.30	.81900	3.3113724	0.7048668
18	6.3911	33.745	156.47	1.3023	3.2106662	0.8055730
19	8.2889	43.765	120.64	2.1904	3.1099462	0.9184861
20	10.163	53.658	98.401	3.2926	3.0092384	1.0070008
21	12.815	67.660	78.037	5.2355	2.9085386	1.1077006
22	16.152	85.283	61.911	8.3208	2.8080083	1.2082306
23	20.377	107.59	49.087	13.238	2.7071016	1.3091371
24	25.695	135.67	38.918	21.050	2.6063921	1.4098477
25	32.400	171.07	30.864	33.466	2.5056925	1.5105464
26	40.868	215.79	24.469	35.235	2.4048508	1.6113881
27	51.519	272.02	19.410	84.644	2.3042751	1.7119646
28	64.966	343.02	15.393	134.56	2.2035496	1.8126899
29	81.921	432.54	12.207	213.96	2.1028452	1.9133940
30	103.30	545.39	9.6812	340.25	2.0021661	2.0140731
31	127.27	671.99	7.8574	528.45	1.9015128	2.1047264
32	164.26	867.27	6.0880	860.33	1.8007171	2.2155221
33	207.08	1093.4	4.8290	1367.3	1.7000977	2.3151415
34	261.23	1379.3	3.8281	2175.5	1.5992279	2.4170113
35	329.35	1738.9	3.0363	3458.5	1.4985862	2.5176530
36	415.24	2192.5	2.4081	5497.4	1.3979400	2.6182992
37	523.76	2765.5	1.9093	8742.1	1.2971037	2.7191355
38	660.37	3486.7	1.5143	13772.	1.1964525	2.8197867
39	832.48	4395.5	1.2012	21896.	1.0958665	2.9203727
40	1049.7	5542.1	.9527	34823.	0.9951963	3.0210429

* Calculated on the basis of Dr. Matthiessen's standard, viz.; 1 mile of pure copper wire of 1-16 inch diameter equals 13.59 Ohms at 15.5° C. or 59.9° Fahr.

TABLE VI.

Soft annealed wire for tying line at insulators is made. It is especially recommended to use this annealed tie wire, for an aluminum line tied with too hard wire will become dented and consequently will break with less strain than if the cross-section had been unimpaired.

The co-efficient of expansion of aluminum is .0000231; therefore, in stringing aluminum wires at ordinary temperatues, a little greater deflection should be allowed.

In this connection it should be borne in mind that with aerial lines the snow and ice load is practically as heavy on small wire as on larger sections, so that no objection can be raised on this score against the use of aluminum on account of its larger section.

TABLE OF RESISTANCES OF PURE ALUMINUM WIRE.*

Pure aluminum weighs 167.111 pounds to the cubic foot. The conductivity of pure aluminum is 60% of the conductivity of pure copper.

Am. Gauge, B. & S. No.	Resistance at 75° F.				Log d^2.	Log **R**.
	R Ohms 1000 Ft.	Ohms per mile.	Feet per Ohm.	Ohms per lb.		
0000	.08177	.43172	12229.8	.00042714	5.3255157	$\bar{2}$.912594
000	.10310	.54440	9699.0	.00067022	5.2248000	$\bar{1}$.013259
00	.13001	.68645	7692.0	.00108116	5.1241128	$\bar{1}$.113977
0	.16385	.86515	6245.4	.0016739	5.0236310	$\bar{1}$.219715
1	.20672	1.09150	4637.35	.0027272	4.9226953	$\bar{1}$.315382
2	.26077	1.37637	3836.22	.0043441	4.8219914	$\bar{1}$.416258
3	.32872	1.7357	3036.12	.0069057	4.7212664	$\bar{1}$.516826
4	.41448	2.1885	2412.60	.0109773	4.6205733	$\bar{1}$.617504
5	.52268	2.7597	1913.22	.017456	4.5198542	$\bar{1}$.718236
6	.65910	3.4802	1517.22	.027758	4.4191300	$\bar{1}$.818951
7	.83118	4.3885	1203.12	.044138	4.3183973	$\bar{1}$.919695
8	1.06802	5.5355	964.18	.070179	4.2177208	0.028579
9	1.32135	6.9767	756.78	.111561	4.1170723	0.121018
10	1.66667	8.8000	600.00	.17467	4.0162392	0.221849
11	2.1012	11.0947	475.908	.28211	3.9156109	0.322467
12	2.6497	13.9900	377.412	.44856	3.8149065	0.423197
13	3.3412	17.642	299.298	.71478	3.7141956	0.523902
14	4.3180	22.800	231.582	1.16225	3.6135004	0.635283
15	5.1917	27.462	192.612	1.7600	3.5127778	0.715310
16	6.6985	35.368	149.286	2.8667	3.4121076	0.825978
17	8.4472	44.602	118,380	4.5588	3.3113724	0.926713
18	10.6518	56.242	93.882	7.2490	3.2106662	1.027423
19	13.8148	72.942	72.384	12.1916	3.1099462	1.140345
20	16.938	89.430	59.0406	18.328	3.0092384	1.228862
21	21.358	112.767	46.8222	29.142	2.9085386	1.329561
22	26.920	142.138	37.1466	46.316	2.8080083	1.430075
23	33.962	179.32	29.4522	73.686	2.7071016	1.531006
24	42.825	226.12	23.3508	117.170	2.6063921	1.631697
25	54.000	285.12	18.5184	186.28	2.5056925	1.732394
26	68.113	359.65	14.6814	296.32	2.4048508	1.833230
27	85.865	453.37	11.6460	485.56	2.3042751	1.933816
28	108.277	571.70	9.2358	749.02	2.2035496	2.034536
29	136.535	720.90	7.3242	1190.97	2.1028452	2.135244
30	172.17	908.98	5.8087	1893.9	2.0021661	2.235957
31	212.12	1119.98	4.7144	2941.5	1.9015128	2.326582
32	273.97	1445.45	3.6528	4788.9	1.8007171	2.437703
33	345.13	1822.3	2.8974	7610.7	1.7000977	2.537983
34	435.38	2298.8	2.2969	12109.4	1.5992279	2.638868
35	548.92	2898.2	1.8218	19251.	1.4985862	2.729508
36	692.07	3654.2	1.4449	30600.	1.3979400	2.840150
37	872.93	4609.2	1.1456	48661.	1.2971037	2.940979
38	1100.62	5811.2	.9086	76658.	1.1964525	3.041638
39	1387.47	7325.8	.7207	121881.	1.0958665	3.142224
40	1749.50	9236.8	.5716	193835.	0.9951963	3.242914

* Calculated on the basis of Dr. Matthiessen's standard, viz.: 1 mile of pure copper wire of $\frac{1}{16}$ inch diameter equals 13.59 ohms at 15.5° C, or 59.9° Fahr.

TABLE VII.

Aluminum is not acted upon in dry air and the corrosion in moist air is by the formation of the oxide of aluminum—alumnia, a harmless salt which forms an impenetrable coating on the metal and protects it from corrosion to a considerable extent. Ammonia solutions act only upon the surface of aluminum, forming a coating which resists corrosion from dilute mineral acids, dilute solutions of organic acids, as well as moist and dry air. Sulphurous acids, such as locomotive flue gases, etc., will have no effect on aluminum.

Aluminum is reduced by electrolytic methods from an ore that is practically free from impurities. Thus, aluminum as it is reduced, is almost chemically pure and absolutely uniform in composition. In this respect it has the advantage over all other common metals which are reduced from impure ores and are necessarily not uniform in chemical composition.

The following statements, which are in accord with the opinions of electricians who have given these questions careful study, refer to the relative properties of aluminum and copper wire of equal conductivity when used in the transmission of alternating currents:

STRANDED ALUMINUM WIRE.

DIAMETER AND PROPERTIES.

CONDUCTIVITY AT 62 IN THE MATTHIESSEN STANDARD SCALE.

Number B. & S. Gauge.	Circular Mills.	Diameters		Weight in Pounds.			Resistance in Ohms at 75° F. per 1,000 Feet
		Decimal Parts of an Inch	Nearest 32nd of an Inch.	Bare.		Triple Braid Insulated	
				Per 1,000 Feet	Per Mile	Per 1,000 Feet	
	100000	1.152	1 5/32	920.	4860	1408	.01675
	95000	1.125	1 1/8	874	4617	1340	.01763
	90000	1.092	1 3/32	828.	4374	1270	.01861
	85000	1.062	1 1/16	782.	4131	1202	.01969
	80000	1.035	1 1/32	736.	3888	1135	.02092
	75000	1.000	1	690.	3645	1067	.02232
	70000	.963	31/32	644.	3402	1001	.02392
	65000	.927	15/16	598.	3159	938	.02575
	60000	.894	29/32	552.	2916	878	.02789
	55000	.855	7/8	506.	2673	806	.03044
	50000	.819	13/16	460.	2430	740	.03347
	45000	.770	25/32	414.	2187	665	.03720
	40000	.728	3/4	368.	1924	567	.04184
	35000	.679	11/16	322.	1701	502	.04782
	30000	.630	5/8	276.	1458	438	.0558
	25000	.590	19/32	230.	1215	375	.06698
0000	211600	.530	17/32	195.	1028	280	.07912
000	167805	.470	15/32	155.	816	232	.09958
00	133079	.420	7/16	123.	647	192	.12563
0	105534	.375	3/8	97	513	155	.1584
1	83694	.330	11/32	77.	407	132	.2004
2	66373	.291	5/16	61.	323	108	.2515
3	52634	.261	9/32	48.5	256	88	.3182
4	41742	.231	1/4	38.5	203	72	.4012

TABLE VIII.

The self-induction in a circuit is less with large wire than with small ones, and it is decreased when the wires are placed closer together. If the wires are the same distance apart in both cases, then the self-induction will be less in an aluminum circuit than in a copper circuit, and the resulting drop in voltage in the line will be less; though the difference is usually quite small, it is in favor of aluminum. If the distance between the wires in an aluminum circuit is 25 per cent. greater than in a copper circuit the self-induction will be the same in the two cases. The separation of the wires is sometimes desirable, especially if spans are increased in length.

The induction in one circuit caused by "transformer action" from current in an adjacent circuit is the same whether either

TABLE OF WEIGHTS OF WEATHERPROOF ALUMINUM WIRE.

Number B. & S. Gauge.	Triple Braid.		Double Braid.	
	Weight per 1,000 Feet.	Weight per Mile.	Weight per 1,000 Feet.	Weight per Mile.
0000	284	1497	266	1402
000	234	1235	218	1151
00	195	1031	169	893
0	162	856	127	671
1	131	694	103	546
2	110	581	90	475
3	89	470	74	390
4	72	380	62	327
5	63	333	55	291
6	56	294	45	236
8	37	196	35	186
10	29	154	23	122
12	19	101	16	86
14	16	86	11	60
16	10	50	8	40
18	8	40	7	35

TABLE IX.

or both are copper, provided the wires maintain the same relative positions in all cases. As the effect of mutual induction is neutralized by transposition of the wires of one circuit it is usually eliminated entirely. Mutual induction is therefore no factor whatever in the choice between aluminum and copper.

An alternating current does not flow uniformly in a conductor as there is a greater density near the surface. The increase in wires less than one-half or three-quarters of an inch in diameter is so slight as to be negligible and it is the same for the aluminum and the copper conductors of equal conductivity.

The quantity of heat produced in two wires being the same, the increase in temperature will be greater in the wire having less surface. The copper wire will therefore heat more than the aluminum wire. The increased temperature will in turn increase the resistance, so that if the wires were of equal resistance when carrying no current the resistance of the copper wire will be greater when the wires carry equal currents. This difference is slight, but it is in favor of aluminum.

The capacity in a circuit is greater with large wires than with small wires, and the charging current in an aluminum circuit is consequently greater than in a corresponding copper circuit if the wires are the same distance apart in the two cases. The difference is not great: about 10 per cent. The charging current is often too small to be of any consequence, and it is useful in neutralizing the lagging current caused by self-induction in load and circuit. The slight difference between aluminum and copper is therefore usually in favor of the former.

Acknowledgement must be made to the Pittsburg Reduction Company, manufacturers of aluminum, and to John Martin, its Pacific Coast agent, for the valuable information and tables presented herewith.

Fraternal

CONVENTION OF THE TRANSMISSION ASSOCIATION.

THE Third Annual Convention of the Pacific Coast Electric Transmission Association was held at the Cliff House, San Francisco, on June 20-21, and was signalized by its large attendance and by the especial value of its papers and the liberality of the discussions of them. During the first day the convention was presided over by W. Frank Pierce, President, and among the full or associate members present were the following corporations by duly accredited representatives:

Blue Lakes Water Company, San Francisco, Cal.
Central California Electric Company, Sacramento, Cal.
General Electric Company, San Francisco, Cal.
Nevada County Electric Power Company, Nevada City, Cal.
Power Development Company, Bakersfield, Cal.
Roeblings' Sons' Company, The John A., San Francisco, Cal.
Sacramento Electric, Gas and Railway Company, Sacramento, Cal.
Salt Lake City Water and Electric Power Company, Salt Lake City, Utah.
Standard Electric Company of California, San Francisco, Cal.
Washburn & Moen Manufacturing Company, San Francisco, Cal.
Westinghouse Electric and Manufacturing Company, San Francisco, Cal.
Yuba Power Company, San Francisco, Cal.

Among the individuals who attended the convention were noted:

Angus, Wm., secretary The Pacific Syndicate, San Francisco, Cal.
Adams, Frank P., superintendent Stockton Gas and Electric Company, Stockton, Cal.
Barbour, F. F., manager Power and Mining Department, General Electric Company, San Francisco, Cal.
Beal, C. N., secretary and treasurer Power Development Company, Bakersfield, Cal.
Bowie, A. J., Jr., electrical engineer, San Francisco, Cal.
Bullock, T. S., general manager Sierra Railway Company, Jamestown, Cal.
Cory, Prof. C. L., professor of electrical engineering, University of California, Berkeley, Cal.
Edgar, W. H., Dearborn Drug and Chemical Works, Chicago, Ill.
Elder, R. B., Westinghouse Electric and Manufacturing Company, San Francisco, Cal.
Ellis, Geo. B., vice-president Redlands Electric Light and Power Company, Redlands, Cal.
Gilbert, C. P , general manager Standard Electric Company of California, San Francisco, Cal.
Heger, W. S., manager Westinghouse Electric and Manufacturing Company, San Francisco, Cal.
Hicks, Lewis A., C. E., Kern County Land Company, Bakersfield, Cal.
Hitzroth, L. D., assistant superintendent San Francisco Gas and Electric Company, San Francisco, Cal.
Hutton, C. Wm., electrical engineer Sacramento Electric Railway and Gas Company, Sacramento, Cal.
Jones, R. M., electrical engineer Salt Lake City Water and Electric Power Company, Salt Lake City, Utah.
Keith, Dr. N. S., electrical engineer, San Francisco, Cal.
Lamson, A. G., president Salt Lake City Water and Electric Power Company, Salt Lake City, Utah.
Lee, F. V. T., manager Pacific Coast agencies for Fred M. Locke, Pittsburg Reduction Company, and the Stanley Electric Manufacturing Company, San Francisco, Cal.
Low, Geo. P., editor and proprietor THE JOURNAL OF ELECTRICITY, POWER AND GAS, San Francisco, Cal.
Martin, John, president Yuba Electric Company, and Pacific Coast agent for Fred M. Locke, Pittsburg Reduction Company, and the Stanley Electric Manufacturing Company, San Francisco, Cal.
Mason-Gardiner, John, hydraulic engineer, Los Angeles, Cal.
Masson, R. S., superintendent Independent Electric Light and Power Company, San Francisco, Cal.
Mortimer, J. D., University of California, Berkeley, Cal.
Perrine, Dr. F. A. C., electrical engineer Standard Electric Company of California, San Francisco, Cal.
Pierce, W. Frank, president Blue Lakes Water Company, San Francisco, Cal.
Poniatowski, Pce. A., president Standard Electric Company of California, San Francisco, Cal.
Scribner, H. D., agent Westinghouse Electric and Manufacturing Company, San Francisco, Cal.
Sharp, E. C., John A. Roeblings' Sons' Company, San Francisco, Cal.
Sloan, Chas. F., Pacific Coast agent Hemingway Glass Company, Pass & Seymour, and the Standard Underground Cable Company, San Francisco, Cal.
Van Norden, Dr. Chas., president Central California Electric Company, Sacramento, Cal.
Wallis, G. H., Washburn & Moen Manufacturing Company, San Francisco, Cal.

In this issue of the JOURNAL is presented four of the six papers constituting those read during the two days' session of the convention, and the titles of the papers, with their authors, are:

"Tests and Calculations for a Forty-Mile Aluminum Transmission Line," by Dr. F. A. C. Perrine.
"Electric Lighting versus Gas," by John Martin.
"Hints on Long-Distance Transmission," by R. W. Van Norden.
"On the Determination of a Fair Return for Current Supply," by C. Wm. Hutton.
"Regulation of Alternating-Current Machinery," by Prof. C. L. Cory.
"Electrically-Driven Centrifugal Pumps," by L. A. Hicks.

As stated, these papers were freely discussed, as will appear in the report of the transactions of the Association to be presented in the next number of the JOURNAL.

During the executive meeting of the Association, held in the afternoon of the first day, the following corporations were elected to full membership:

Butte County Electric Power Company, Chico, Cal.
Kern, Rand Company, Los Angeles, Cal.
Redlands Light and Power Company, Redlands, Cal.
Snoqualmie Falls Power Company, Seattle, Wash.

The following were elected to associate membership:

San Francisco Gas and Electric Company, San Francisco.
Wagner Electric Manufacturing Company, St. Louis, Mo.

The Association also, in its executive session, elected Prof. C. L. Cory, of the University of California, to honorary membership.

The election of officers for the year 1899-1900, which was held during the executive session, resulted in the election of Pce. A. Poniatowski, President; A. G. Lamson, Vice-President; Geo. P Low, Secretary, and Wm. Angus, Treasurer. The Executive Committee for the ensuing term is to consist of the president, *ex-officio*, and Messrs. Gilbert and Beal.

The social functions of the convention consisted of a banquet given by the Association at the conclusion of the afternoon session of the first day's proceedings. Covers were laid for fifty guests; the repast was spiced with the fun and merriment of many after-dinner speeches, and the occasion was most enjoyable.

One of the many good results of which the great success of the Third Annual Convention has been prolific, has been the determination to hold at least quarterly, or perhaps bi-monthly, meetings of the Association in the future, due announcement of which, together with full reports of their proceedings, will be made in these columns.

Literature.

ELECTRICAL AND MECHANICAL VEST-POCKET MANUAL, by Sidney Sprout, E. E. Size, 2¾x5 inches; leather, round corners and gilt edges; 204 pages. Published by Sprout & Stevens, 519 Emma Spreckels Building, San Francisco. Price, $1.00.

Of the many engineers' hand-books placed upon the market in recent years, the "Electrical and Mechanical Vest-Pocket Manual" is certainly the most complete and comprehensive. Its 204 pages are filled with information of the utmost value to electricians, engineers, and mechanics in general. The author has compiled a mass of tables and data never before published, and new indeed must be the problem not touched upon by this little book. Calculations for almost the entire field of engineering are to be found within its covers, and the book is indexed in such a perfect manner that it is but the work of a moment to find any desired subject. The "Manual" will undoubtedly be eagerly sought for by engineers.

Industrial

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

PREPARE FOR THE HOT WEATHER.

The use of fan motors during the summer months has become a necessity wherever a central station renders the use of such a convenience possible. The discomforts of the heated season are, in a large measure, overcome wherever fan motors have been introduced.

The Sprague-Lundell Fan Motor, '99 model, more than upholds the reputation which this class of goods has made for the Sprague Electric Company. For several years this company has been turning out high-class electrical machinery, claiming that a finished machine at a reasonable price would win more favor than a cheaply constructed affair which would sell at a low figure and last but a single season. The truth of this contention has been more than demonstrated. The Sprague-Lundell fans have been adopted by the United States Government for use on the transports, and statistics prove their efficiency.

The Brooks-Follis Electric Corporation, western agents for the Sprague Electric Company, is fully prepared to meet any demands which may be made upon it for Sprague material, their storerooms at 523-525 Mission street, San Francisco, being handsomely stocked with fan and power motors and ceiling fans.

The Brooks-Follis company also handles the lamps of the Fostoria Incandescent Lamp Company. The Fostoria lamp has demonstrated its many good qualities and is in general use throughout the coast. The popularity of this lamp has induced the Brooks-Follis Electric Corporation to carry a full stock at their storerooms in connection with electrical apparatus of every description necessary for construction and maintenance of light and power plants.

THE KASTEN SLOW-SPEED MOTOR.

Messrs. Ferdinand Kasten & Company, 519 Howard street, San Francisco, are bringing out a line of slow-speed bi-polar motors which are meeting with a ready sale. As seen from the half-tone engraving presented below, which is of a one-horsepower motor, there is nothing especially new or original in the general design of the machine. It is of the familiar Manchester type of field and frame, but by using the best of materials, strictly first-class workmanship and correct proportions, the manufacturers have been able to reduce the speed to a remarkable degree below that ordinarily used in motors of this size.

The one-horsepower motor illustrated weighs only 160 pounds and runs at 1000 revolutions per minute, and its efficiency is guaranteed by the makers to be 75 per cent. The sizes of the Kasten dynamos from ten-horsepower up are of the multipolar type, and the 15-horsepower motor runs at 650 revolutions per minute and with a claimed efficiency of 90 per cent. The armatures of all sizes of machines are slotted, and carbon brushes are used, which run absolutely without sparking; the machines have self-oiling bearings and they require no attention whatever.

One of the interesting novelties brought out by the company is the Kasten motor-starting box, which is so arranged that through its use a motor may be controlled from any number of points by push buttons with auxiliary circuits, or by derived line currents as in the Sechrist automatic switch. The Kasten device possesses all the functions of starting rheostats with the added improvement described.

REFILL YOUR BURNED-OUT LAMPS.

The Pacific Incandescent Lamp Co. announces to the electric lighting trade, and to consumers of incandescent lamps in particular, that its new and splendidly equipped factory occupying the third floor of the Gutzkow Building, 933 Market street, San Francisco, has been working to full capacity for several months past, and that it is prepared to refill lamps or to supply refilled lamps in all voltages and candlepowers from stock.

Refilled lamps are as good as new ones in every way, and they are much cheaper. Write for prices, or better still, send in a trial lot of burned-out lamps to be refilled.

A COMPOUND ENGINE WANTED.

On an advertising page of this issue appears an announcement that the Electric Improvement Company, San Jose, Cal., desires to receive propositions for the purchase of a good second-class, high-speed compound engine of a capacity ranging from 150 to 250 horsepower, as well as a 500-volt direct-current generator for the same. Parties having such apparatus (which must be in strictly first-class condition) for sale will find a ready purchaser in the company named.

THE JOURNAL OF ELECTRICITY, POWER AND GAS.

VOLUME VIII. SAN FRANCISCO, AUGUST, 1899. NUMBER 2.

The Regulation of Alternating-Current Generators.[*]

BY PROF. C. L. CORY.

The following paper is not a theoretical one, notwithstanding the fact that the theory of lagging and leading currents must be for a moment discussed before the results of the tests and experimental work are considered. The practical bearing of the regulation of alternating-current generators is of great importance to all of us who have to do with the operation of transmission plants.

Figure 1 shows a circuit containing only resistance, the entire resistance being 40 ohms. The electromotive force is 1000 volts, the current 25 amperes. The power in watts is represented by the product of 1000 volts and 25 amperes, or 25,000 watts. The product of the resistance and the current squared, or 40 ohms multiplied by 25^2 is similarly 25,000 watts. Reference to the figure will show that the power curve is entirely above the neutral line, and at all times is represented by the product of the current and electromotive force.

Figure 2 shows the same alternator connected to the circuit containing 40 ohms resistance and a self-induction of $\frac{1}{10}$ of a henry. If the frequency of the alternator is approximately 48, this self-induction produces a reactance of 30 ohms. This self-induction in the circuit reduces the current to 20 amperes and the apparent watts will be 1000 volts multiplied by 20 amperes, or 20,000 watts. The real power in watts, however, is the product of the current squared and the resistance, or 16,000 watts. The power factor then, is the real watts divided by the apparent watts, or 0.8.

Referring to the curves of electromotive force, current and power, it is noted that the current is zero when the electromotive force has a positive value. The angle of lag in this case is 32 degrees and 52 minutes. We note then, that the current is reduced, due to the added self-induction, and the power is also less. It should be remembered that the self-induction absorbs no energy. On this figure it can be observed that the current curve may be broken up into two other curves. The power current, or current which is in phase with the electromotive force and the reactive current, or current which lags 90 degrees behind the electromotive force. The power current is 16 amperes and the reactive current 12 amperes.

If we replace the self-induction by a condenser, the capacity of which is 111 micro-farads, we have a condition of a circuit containing resistance and capacity. The curves are shown in Figure 3. If the frequency is again approximately 48, we have 40 ohms resistance and 30 ohms reactance. The apparent watts will be represented by the product of 1000 volts and 20 amperes, or 20,000 watts. The real watts will be represented by the product of the 40 ohms resistance and the 20 amperes squared, or 16,000 watts. The power factor, which is again the real watts divided by the apparent watts, is 0.8. The figure shows the curves of electromotive force, current and power. Lagging currents then are caused by a self-induction in the circuit, while capacity causes a leading current. In either case we have chosen, if we combine the 30 ohms reactance to the 40 ohms resistance, we find the result is 50, and we can say the *impedance* of the circuit is 50 ohms.

Figures 5, 6, and 7 show the curves taken from a constant-potential, direct-current multipolar generator. Figure 8 shows the relation between the drop in the armature due to resistance alone, and the drop due to the impedance of the armature. These were taken from the 30-kilowatt single-phase alternator. Figure 9 is the magnetization curve, ascending and descending, taken from the ½-kilowatt two-phase alternator. Figures 10 and 11 are the regulation curves, taken from the same machine. In taking the curves shown in Figure 7 it was impossible to maintain a constant power factor, but the similarity of the curve taken with unity power factor and with the power factor varying from 0.6 to 0.9 is clearly shown.

Figure 12 shows the magnetization curves of the one-horse-power C.-W. motor-alternator. Figure 13 shows the regulation curves of this same machine. Figures 14, 15, 16 and 17 are the curves taken from the 30-kilowatt single-phase alternator. Figure 18 is the curve showing the relation between the demagnetizing effect and the power factor. Figure 19 shows a cross-section of the armature core of the 30-kilowatt single-phase alternator. Figures 20 and 21 represent graphically the 10-mile, 10,000-volt (at receiving end), 500-kilowatt (at receiving end), single-phase transmission system. The frequency is taken at 60 cycles; the line a pair of No. 1 B. & S. copper conductors strung 18 inches between centers. In Figure 20 the load is non-inductive, or the ordinary lighting load, giving a power factor of .99. In Figure 21 the load is inductive, giving a power factor of 0.8.

THE electromotive force produced in any given dynamo is directly proportional to three factors: the speed, or the number of revolutions per minute; the number and arrangement of conductors on the armature; and, the strength of the magnetic field in the space through which the conductors are moved. As is well known, the conductors in which the electromotive force is produced are sometimes stationary, in which case the magnetic field is caused to move or to change in strength, which is equivalent in every way to the movement of the conductors when the magnetic field is stationary. As long as these three factors are constant, the electromotive force generated in the coils of an armature is constant.

Let us first distinguish clearly between the two expressions, "the electromotive force," and "the difference in potential" (or "voltage") "at the terminals of the machine." The electromotive force is the entire electrical pressure produced. The difference of potential at the terminals, or the voltage at the commutator or collecting rings, is less, on account of the drop in pressure through the armature, and, in some machines, also the drop in pressure in series turns. In direct current constant potential machines, this drop is equal to the product of the resistance, in ohms, of the armature, and perhaps of the series coils, multiplied by the current through the armature.

---

[*] A paper read before the Third Annual Convention of the Pacific Coast Electric Transmission Association, San Francisco, June 20-21, 1899.

In alternating current generators, this drop is equal to the impedence of the armature, multiplied by the current through the armature. It is evident, therefore, that this drop in pressure in the armature, in alternating current generators is not alone dependent upon the ohmic resistance, but also upon the inductance or self-induction of the armature as well.

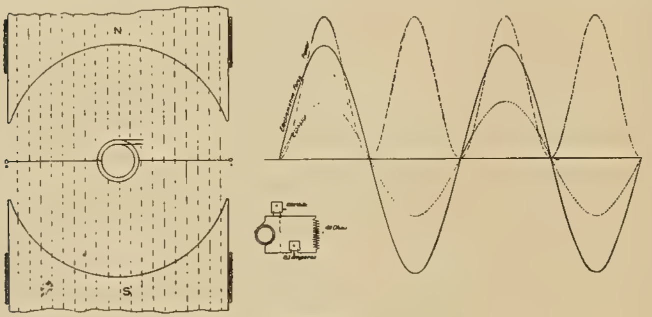


FIGURE 1.

Therefore let us understand this distinction: a constant potential generator is one which gives us a constant difference of potential at the terminals of the machine, or collecting rings; the entire electromotive force generated by the armature being of practically no importance, whether it is constant or not. By this constant potential at the collecting rings, it is understood that it refers to all loads, from no load to full load; and not only that, but the load is to be of any character. And in alternating current machines the load may be either such that the power factor is unity or the power factor less than unity.

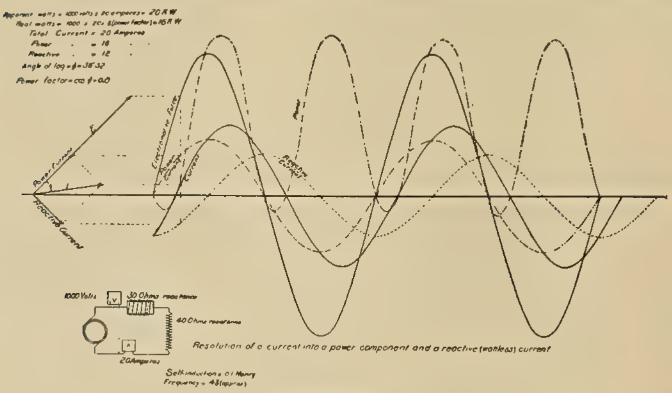

Apparent watts = 1000 volts × 20 amperes = 20 K W
Real watts = 1000 × 20 × .8 (power factor) = 16 K W
Total Current = 20 Amperes
Power " = 16 "
Reactive " = 12 "
Angle of lag = ϕ = 36°52
Power factor = cos ϕ = 0.8
E
Power Current
Reactive Current
Electromotive Force
Power Current
Current
Power
Reactive Current
1000 Volts
V
30 Ohms reactance
40 Ohms resistance
A
20 Amperes
Self-induction = 0.1 Henry
Frequency = 48 (approx)
Resolution of a current into a power component and a reactive (wattless) current

FIGURE 2.

Considering the three factors, the speed, the number of armature conductors, and the strength of field, let us take them up in order.

Practically, it is of course best to have the speed constant at all loads. We know how difficult this matter is where electrical energy is generated from water power. Water-wheel governors have what may be called a time element; that is, if given time enough, they will bring the speed up to its original value after it has suffered a reduction by increased load. The very sudden fluctuation of load, lasting but a few seconds, is where the water-wheel governor has its hardest, and, in some respects, its most important work to do.

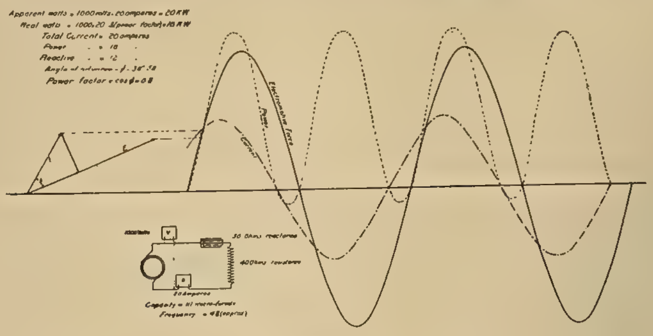

Apparent watts = 1000 volts × 20 amperes = 20 K W
Real watts = 1000 × 20 × .8 (power factor) = 16 K W
Total Current = 20 amperes
Power " = 16 "
Reactive " = 12 "
Angle of advance = ϕ = 36°52
Power factor = cos ϕ = 0.8
E
Electromotive Force
Power
Current
1000 Volts
V
30 Ohms reactance
40 Ohms resistance
A
20 Amperes
Capacity = 81 micro-farads
Frequency = 48 (approx)

FIGURE 3.

Steam-driven generators usually have an almost constant speed at all loads. The character of mechanical power used to drive alternating current generators, it is very evident, has nothing to do with the inherent regulation of the generator itself; and we are to concern ourselves, for the present, only with the generator.

Considering the number and arrangement of conductors on the armature, it need only be said that, with one or two notable exceptions, it is not possible, practically, to change the number of conductors on the armature while the machine is in operation. Where the armature coils are stationary, this change in the number of armature conductors is possible, and is, as is well known, effected in some types of alternating current generators, both single-phase and polyphase. Generally speaking, however, this is possible only with particular types, and hence, while of great importance, is not possible of application in general.

Considering the strength of the magnetic field through which the conductors are moved, we find two effects: one is the effect of the ampere turns on the field, an increase of which tends to increase the strength of the magnetic field; the other, the ampere turns of the armature, an increase of which tends to diminish the strength of the magnetic field.

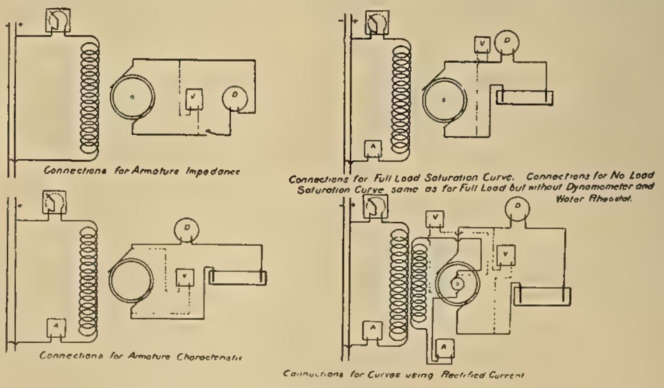

V
D
A
Connections for Armature Impedance
Connections for Full Load Saturation Curve. Connections for No Load Saturation Curve same as for Full Load but without Dynamometer and Water Rheostat.
Connections for Armature Characteristic
Connections for Curves using Rectified Current

FIGURE 4.

This demagnetizing effect of the armature current is of very much greater importance in direct-current machines than in alternating-current machines, providing we speak of alternating machines which are used principally for incandescent lighting—that is, where the power factor is very nearly unity. At one time it was thought impossible to reduce the air gap for the direct-current potential generator below a certain minimum value, inasmuch as a large air gap naturally tends to diminish the demgnetizing effect of the armature current in such machines. At the present time this tendency, which always results in a reduction of the electromotive force of a machine, is counteracted in two ways: 1st, by the use of compound winding; and secondly, by making the number of ampere turns on the field very large as compared with the number of ampere turns on the armature.

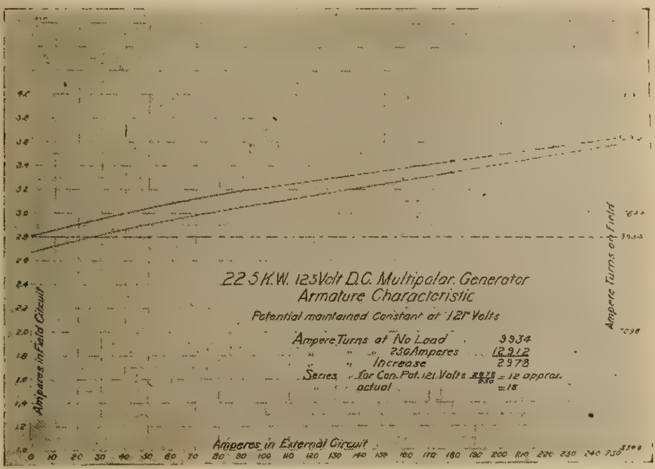


FIGURE 5.

In discussing the regulation of alternating-current generators, I intend to confine myself to two of the effects mentioned above—first, the drop through the armature, and second, the change in the strength of the magnetic field due to the demagnetizing action of the armature current.

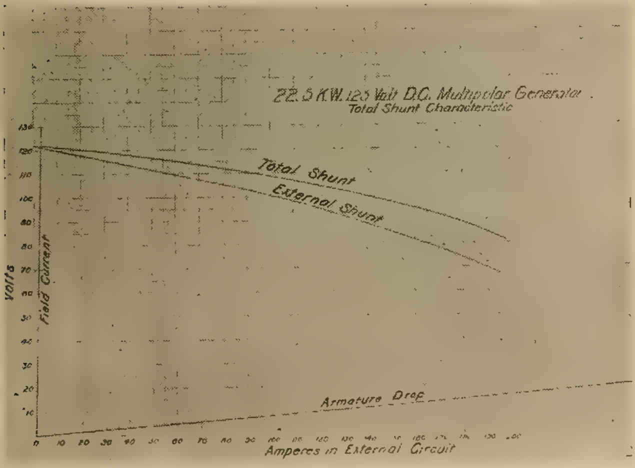


FIGURE 6.

Taking up the first question, of the drop through the armature, as applied particularly to alternating-current generators: As has been said above, it is evident that the loss of pressure in the armature is not alone due to the resistance of the armature, but also to the self-induction of the armature. The self-induction of the armature depends largely upon the character of the armature winding. The self-induction of the armature may be said to depend, approximately, in such cases, as follows: It is proportional to the square of the number of turns in one armature coil, proportional to the area of that coil, and proportional to the permeability or magnetic quality of the material inside and surrounding the coil.

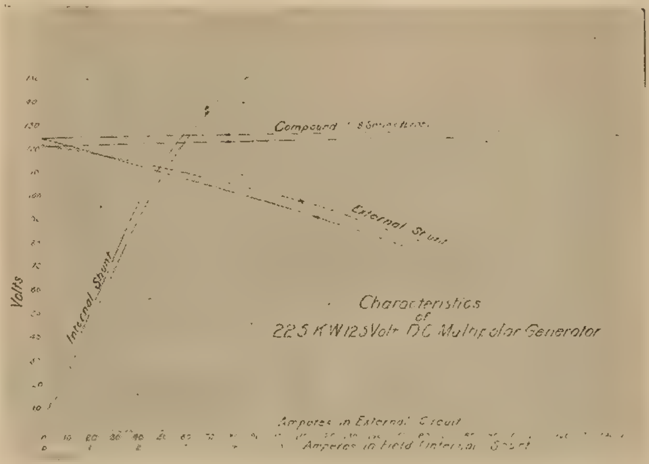


FIGURE 7.

The three types of armature winding that are used in practical work are, the smooth core (the so-called "pancake" coil armature), the slotted armature (such as is largely used at the present time for many constant potential direct-current generators, as well as for constant potential alternating-current generators), and the "unitooth" armature (where the coils are wound upon the armature teeth, the number of coils being comparatively small, and, in the particular machine experimented upon, equal to the number of pole pieces).

With a given number of conductors on an armature, if the coils are of small number, the number of conductors per coil must be large; so that, as might be supposed, the self-induction of an armature so wound

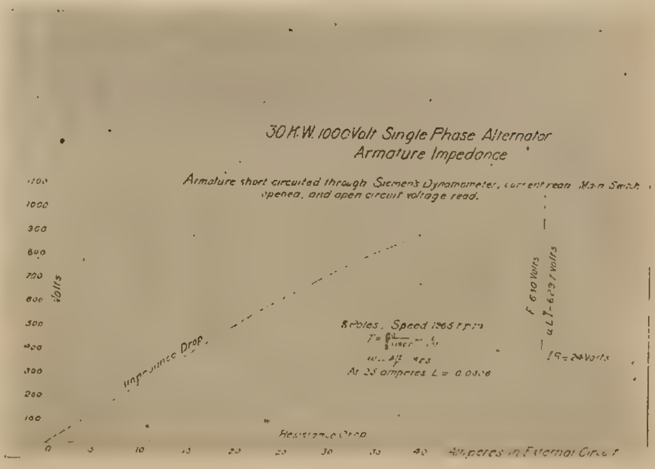


FIGURE 8.

is usually very high—due to the fact that there are a large number of turns in the coil, and that these coils are wound upon a large iron tooth of the armature.

Again, the self-induction of the armatures of the original alternating-current generators built in this country was very small. They were usually smooth-core machines, giving an approximately constant potential when separately excited from a direct-current constant-potential generator.

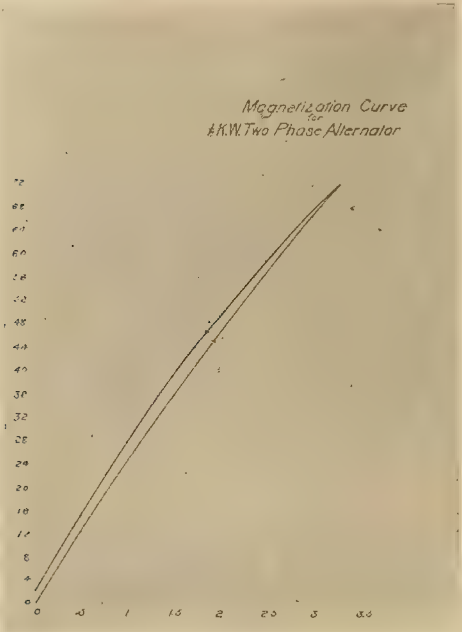


FIGURE 9.

The Stanley alternating-current arc-generator, brought out by the Westinghouse Electric Company in 1889, was the most radical departure from this. In fact, it was a machine designed and constructed to give a constant current, up to a certain limit, no matter what the resistance of the external circuit might be; and the self-induction of the armature was made as large as was possible consistent with good efficiency and successful operation. The armature conductors were wound with a large number of turns in each coil, and placed upon large armature teeth. In fact, the construction of the armature core was almost identical with the machine upon which some of the experiments were made for the present paper.

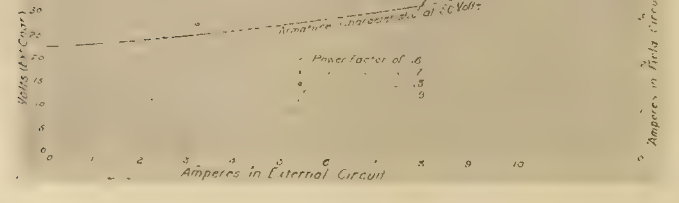


FIGURE 10.

The so-called distributed winding, or the winding which is adopted in a large number of machines made at the present time, where a comparatively small number of turns are placed in each slot, the slots being small and comparatively numerous to each pole piece, is a mean between the original smooth-core armatures

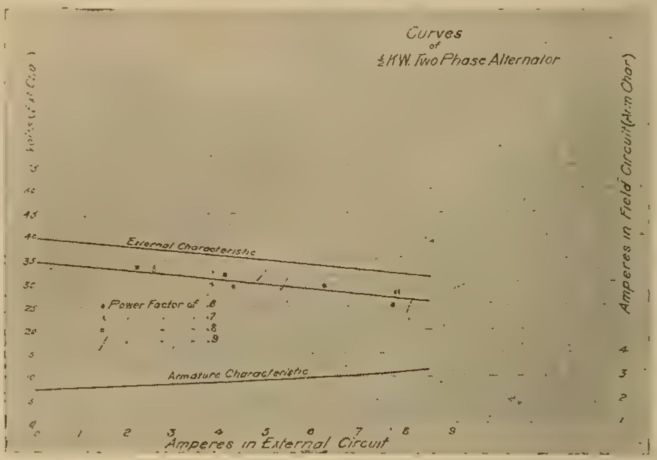


FIGURE 11.

and the alternating arc machine of Stanley. And hence, in taking up the experimental work, I have considered all three of these types. And perhaps it might be well to give a brief description of the machines, with some data regarding their constants.

The alternator having the smooth core is a small, one-half-kilowatt, two-phase, eight-pole machine, which was built in the Electrical Engineering Laboratory of the University. The winding consists of two layers and eight coils in each phase. The coils are the regular "pancake" coils, the winding of one phase being the lower layer next the smooth core, while the winding of the other phase consists of the second layer on the surface of the armature. During the experimental work the machine was run as a single-phase machine, the two windings being in series. The resistance of the armature was about 1.72 ohms; the voltage about 50; and the current output as high as nine

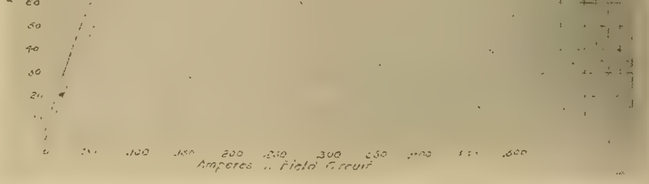


FIGURE 12.

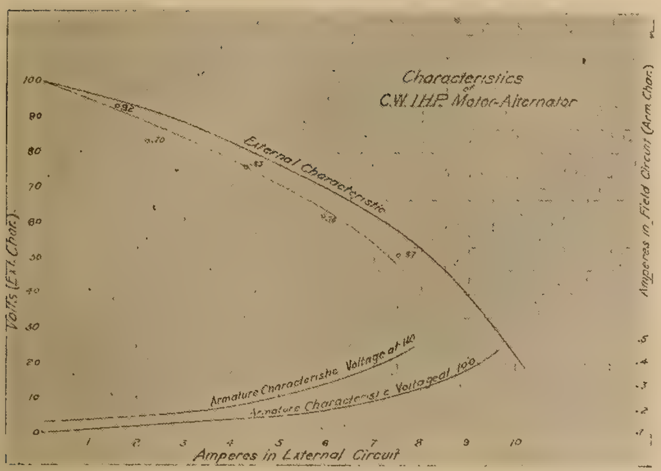


FIGURE 13.

amperes. This machine was separately excited from a 110-volt direct-current circuit. From its magnetization curve, it is evident that the air gap is rather large and that the iron is very lightly saturated. The self-induction of the armature was .0265 henrys. The curves show the regulation of the machine.

The second machine was a one-horsepower Crocker & Wheeler motor-dynamo, which was also equipped with a pulley so that it might be run and operated as a direct-current generator or as an alternating-current generator. During the experimental work, of course, it was operated as an alternating-current generator. It was run above speed considerably, because it was desirable to get the frequency as high as possible, this being a bi-polar machine. It was therefore run at two thousand revolutions a minute, giving about thirty-three cycles. The resistance of the armature was 2.1 ohms, and the self-induction .0323 henrys. The curves show the regulation of this machine.

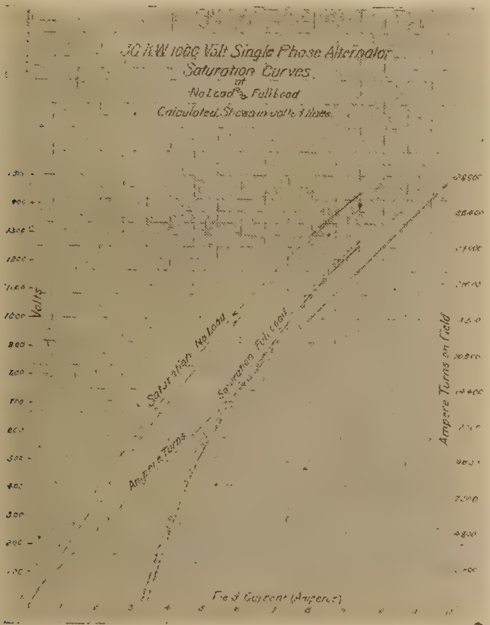


FIGURE 14

The third machine experimented upon was a 30-kilowatt, 1,000-volt, single-phase alternator, of the toothed-armature type. The armature is wound with eight coils of No. 10 wire, 30 turns to the coil. The cross-section of the armature shows the arrangement of the winding.

In the armature, on diametrically opposite parts, is shown the series transformer, which is connected through the rectifier for compounding the machine. The number of turns on the primary of these series transformers is five, and the number on the secondary is fifteen. The secondaries of these transformers are connected in series to the rectifier and at full load give about ten amperes. Inasmuch as the ratio of transformation is 1.3, the rectified current is one-third of the main current—the main current at full load being thirty amperes.

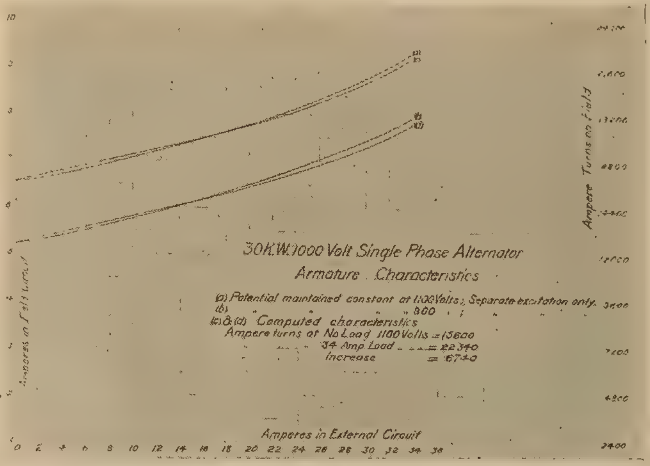


FIGURE 15.

The eight poles of the machine are each wound with 300 turns for the separate excitation, or 2,400 turns total, and 175 turns for the compound or rectified excitation, or 1,400 turns total. The machine ordinarily runs at 2,000 revolutions a minute, which gives a frequency of about 133. The self-induction of the armature is, at full load, .02796 henrys, and the resistance .96 of an ohm. It should be noticed that the ratio of self-induction and resistance of this machine is much greater than the ratio of the self-induction and resistance of the smaller alternators.

In direct-current machinery the difference of poten-

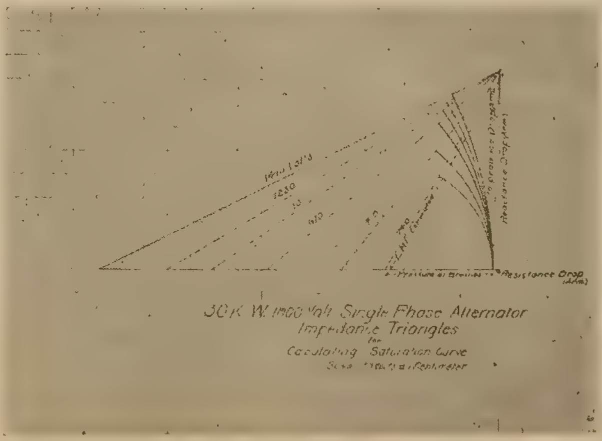


FIGURE 16.

tial at the brushes is equal to the electromotive force of the machine minus the drop in voltage due to the ohmic resistance of the armature. In alternating current machines, where the self-induction of the armature bears any considerable ratio to the resistance of the armature, the impedence drop is larger than the ohmic drop. In order to determine the difference of potential at the brushes of an alternator, at any load, we cannot subtract the impedence drop through the armature from the whole electromotive force produced, because of a difference in phase. In other words, the difference of potential at the collecting rings, at any load, is not equal to the whole electromotive force generated minus the drop through the armature due to its resistance and self-induction. This must be clearly borne in mind in connection with the regulation of alternating-current machines, as regards the loss of pressure in the armature. The method of determining this drop through the armature and the difference of potential at the brushes, is clearly shown by the curves and the construction of the impedence triangles. The computed curves agree so closely with the observed curves that the results are quite satisfactory.

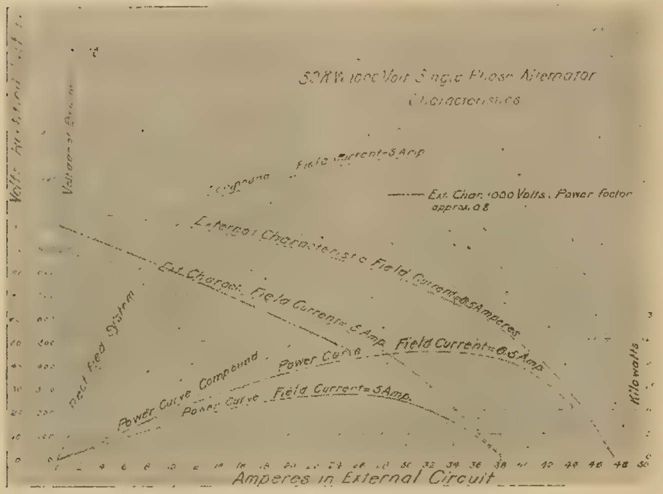


FIGURE 17.

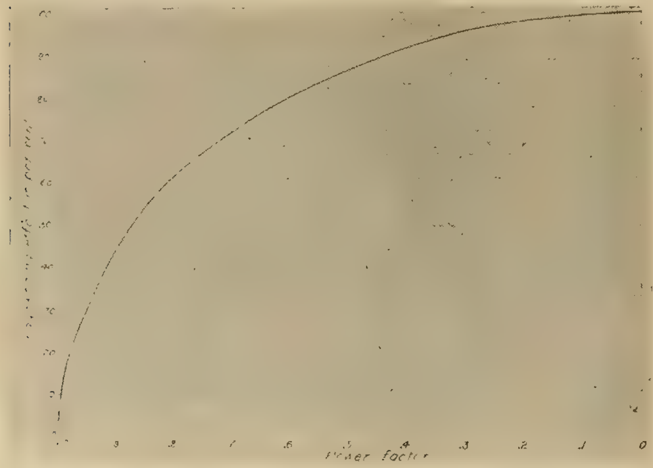


FIGURE 18.

One point might be mentioned here which is apparent. If for any reason a smooth-core alternator is short-circuited, the almost inevitable result is the stripping of the conductors from the armature, due to the fact that the armature current increases far beyond its normal value.

If an alternator having separate excitation only is short-circuited, whose armature has a large self-induction, the current on short circuit is perhaps 200 per cent. of the full-load current, while the difference of potential at the brushes is practically nil. The power, therefore, is very small. Such generators, with only separate excitation, may therefore be short-circuited with no danger whatever.

The type of armature which is the mean between these two is perhaps most used at the present time, and may be said to have many advantages over either of the other forms.

The demagnetizing effect of the armature current in reducing the strength of field depends largely upon the power factor at which an alternating-current generator is operated. If the circuit is such that the capacity affected is large, producing an angle of advance between the current and the applied electromotive force, the tendency of the armature current is to add its effect to the field current in setting up magnetism through the armature and field cores and remainder of the magnetic circuit.

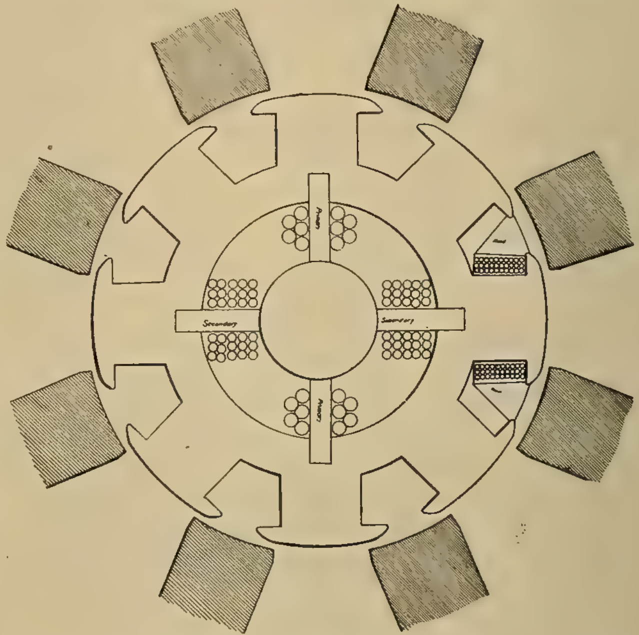


FIGURE 19.

If the external circuit of the alternator has large self-induction, the current will lag behind the electromotive force, and the effect of the armature current will be to counteract the field current in setting up magnetization through the armature and field cores, etc. In mathematical language, this compounding effect of a leading current and demagnetizing of a lagging current is proportional to the sine of the phase angle. The cosine of the angle is always positive, no matter whether it is an angle of advance or an angle

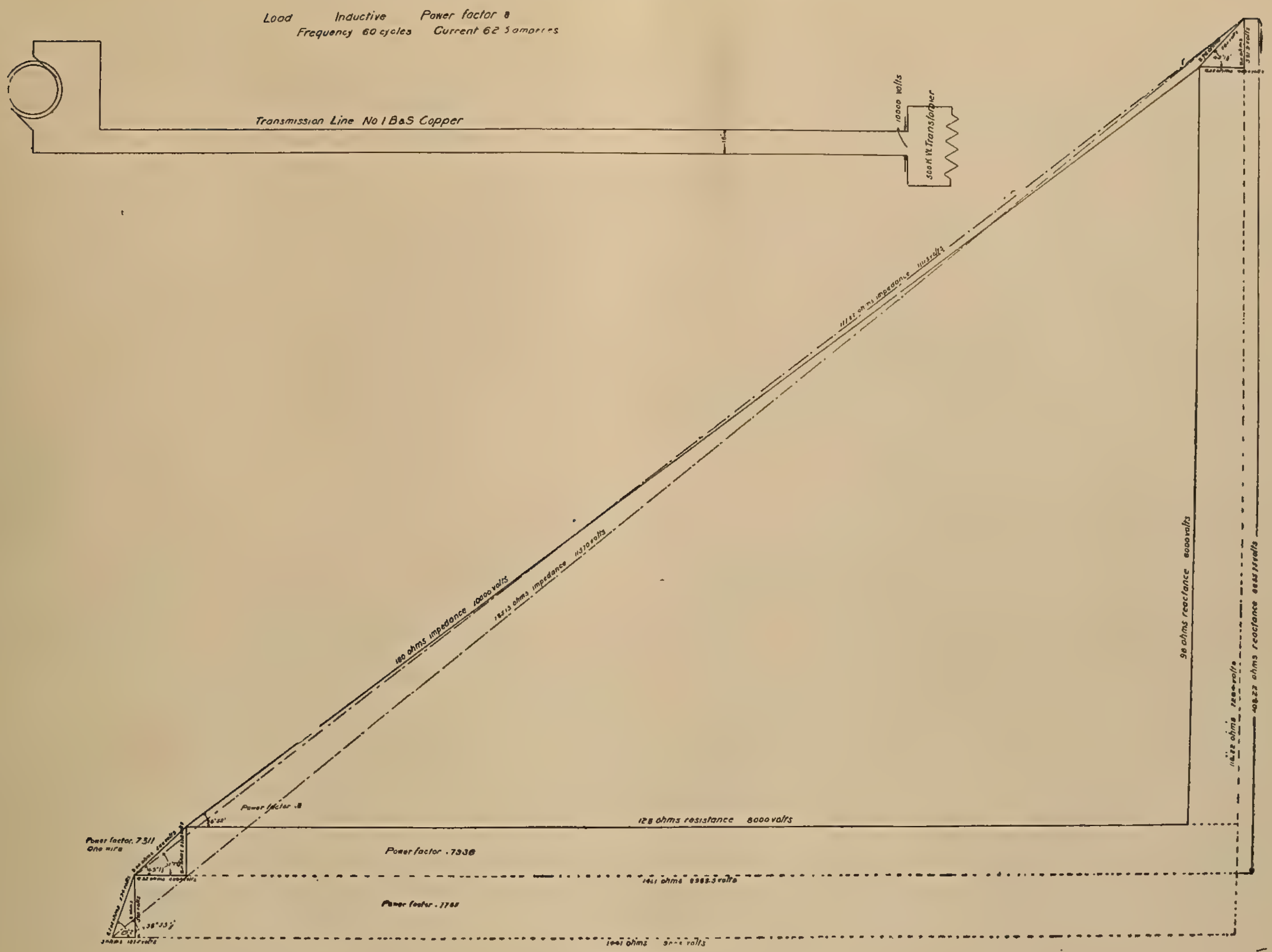

Load Inductive Power factor .8
Frequency 60 cycles Current 62.5 amperes
Transmission Line No 1 B&S Copper
10000 volts
500 K.W. Transformer
180 ohms impedance 10000 volts
183.13 ohms impedance 11370 volts
98 ohms reactance 8000 volts
108.23 ohms reactance
11.22 ohms
Power factor .8
128 ohms resistance 8000 volts
Power factor .7311
One wire
Power factor .7338
Power factor .7768

FIGURE 20.

of lag. Or, in other words, a leading current tends to over-magnetize the field, while a lagging current tends to demagnetize the field.

When an alternator with practically no self-induction in its armature is delivering current to a non-inductive circuit, the current is practically in phase with the electromotive force; the demagnetizing effect of the armature current of such a machine is practically zero, as may be shown by a simple illustration.

The demagnetizing effect of a lagging current is greater in an armature wound with a few coils, each of a large number of turns, than in an armature wound with a comparatively large number of coils of a few turns each. Consider an extreme case: Suppose that the current in an armature is lagging ninety degrees behind the generated electromotive force. The demagnetizing effect of the armature current is then at its maximum. If the armature is so wound that we have one coil for every pole piece, each armature coil containing a large number of turns, the current in this coil is a maximum when it is exactly opposite the pole piece—that is, when it is in position for maximum demagnetizing effect.

If this one coil, containing a large number of turns, is divided up into a number of coils of a few turns each, only a part of the original main coil is in position for maximum demagnetizing effect. This, therefore, is a distinct gain, as regards regulation, in favor of the distributed armature winding, or an armature winding of comparatively few turns in each coil and a large number of such coils or slots in the armature.

It should of course be noted that the form of the electromotive wave will also be affected by such a change in the armature winding. Indeed, in the machine experimented upon, the wave of the electromotive force is very peaked, or, as might be said, the third harmonic is very prominent.

In conclusion, it might be said that our modern dynamo, whether alternating or direct, and, if alternating, whether ploypjase or single phase, should possess five important features:

1. A high efficiency.
2. A low temperature increase when operating at full load.
3. Good commutation (reference only to direct current machines).
4. Good mechanical design and construction.
5. Good regulation.

These five features are interdependent, and each has greater or less importance. Upon the efficiency depends the cost of power; and therefore the efficiency is of prime importance to the commercial success of any installation. Upon the rise in temperature depends the capacity, and in some cases the life, of the machine. In direct-current machines the commutation affects the regulation and capacity of the machine—indeed, in many cases, commutation affects the capacity of a direct current generator far more than the rise in temperature. Mechanical design and construction affects the reliability, the management, and, in a direct way, the operating engineer. The foregoing four features affect only the operating system or the operating company. Regulation, on the other hand, affects the customer, and is of more importance to him than any other matter except, perhaps, reliability of the electrical supply.

TABLE I.

Ten-mile, 10,000-volt (at receiving end), 500-kilowatt (at receiving end), single-phase transmission system; frequency, 60 cycles; line, a pair of No. 1 B. & S. copper conductors, 18 inches between centers.

	Load Non-Inductive Power Factor .99	Load Inductive Power Factor .8
Current in amperes	50.505	62.5
Power current	50.	50.
Reactive current	7.	37.5
Drop in the armature in volts	431.5	534.
Drop in the line in volts	905.	1120.
Watts lost in the armature	7652.	11719.
Watts lost in the line	33414.	51172.
Drop in line in volts in per cent.	9.05	11.2
Watts lost in line in per cent.	6.68	10.23
Total electromotive force of generator in volts	10985.	11570.
Voltage at collecting rings	10752.	11113.
Total apparent watts generated	554798.	723125.
Total real watts generated	541067.	562891.
Power factor of entire system, including armature	.9752	.7785
Power factor of load, including line, from collecting rings	.9821	.7936

TABLE II.

Power Factor in Per Cent. Cosine Angle of Lag.	Angle of Lag in Degrees.	Demagnetizing Effect in Per Cent. of Maximum Sine Angle of Lag.
100	0°	0.0
90	5° 45′	43.6
80	11° 33′	60.0
70	17° 27′	71.4
60	23° 35′	80.0
50	30°	86.6
40	36° 52′	91.7
30	44° 26′	95.4
20	53° 8′	98.0
10	64° 10′	99.5
0	90°	100.0

THE ROTATIVE DIRECTION OF POLYPHASE MOTORS.

Reversing the direction of rotation of induction motors is accomplished in general by interchanging two service leads. In particular, the two leads to be interchanged are as follows: Any two leads on a three-phase motor; the two leads of either phase of a four-wire, two-phase motor; and the two outside leads of a three-wire, two-phase motor. Synchronous motors will run in either direction as started.

The JOURNAL is the only publication that contains the report of the proceedings of the Pacific Coast Electric Transmission Association. Are you a subscriber?

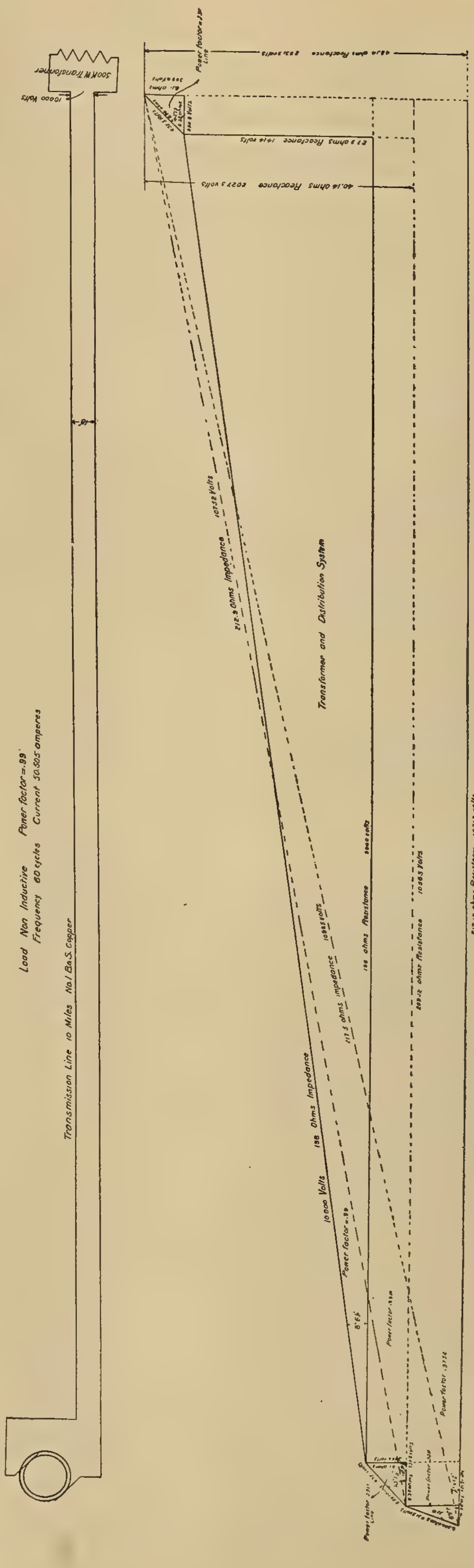

500 K.W. Transformer
10000 Volts
Load Non Inductive Power factor=.99
Frequency 60 cycles Current 50.505 amperes
Transmission Line 10 Miles No.1 B.&S. Copper
Transformer and Distribution System
27.9 ohms Reactance 1414 volts
40.14 ohms Reactance 2027.5 volts
10000 Volts
138 Ohms Impedance
117.5 ohms impedance
10985 volts
138 ohms Resistance
208.12 ohms Resistance
10983 Volts
212.12 ohms Resistance 10713 volts
Power factor=.99
Power factor=.8

FIGURE 21.

Tests and Calculations for a Forty-Mile Aluminum Wire Transmission Line.*

BY F. A. C. PERRINE, D. SC.

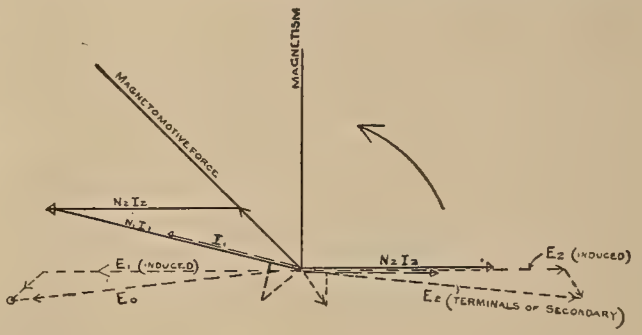
RUNNING from the Blue Lakes power house near the Big Bar bridge on the Mokelumne River to the Stockton sub-station is the line to which reference is made. It is that of the Standard Electric Company of California, and it is particularly pertinent to report on the tests of this line because there has been a great deal of talk about there having been a failure of the wire The line extends from the Blue Lakes plant on the Mokelumne River to the substation in Stockton, a distance given by the engineers as 43½ miles. The line was designed to deliver 1000 kilowatts at 8.8 per cent. C^2R loss, the line being two-phase, arranged at the corners of a rectangle—not a square; one side of the rectangle being 24 inches, the other side 41 inches, giving a distance between phases of 46 inches. This peculiar arrangement was adopted on account of the fact that the line was intended subsequently to be changed to a three-phase line, and to form with two additional wires, two three-phase lines on the one pole line; the wires being then set at the corner of a hexagon giving a distance of 41 inches between the wires of the same phase.

At present the two-phase line occupies four pins, and subsequently it is to occupy but three of the pins when the line is changed to three-phase. All of this was made necessary by the character of machinery, and also to overcome some of the difficulties which were anticipated in connection with the rapid building of the line, which rapid building was made necessary by the condition of the weather. The work began last November and no one had reason to suppose that the winter would be an open winter, which it proved to be.

The wire is 294 mils in diameter, or 86,433 circular mils in area, weighs 419.4 pounds per mile, and the ultimate tensile strength of each wire is 1539 pounds, or 22,700 pounds per square inch. The stress at one per cent. elongation is 800 pounds; conductivity by dimensions is 59.9 per cent. of Matthiessen's standard for soft copper. These quantities are obtained from the tests of a large number of samples. You will notice no elastic limit is given, but the stress is at one per cent. elongation. This is on account of the fact, that, in common with copper and metals of a similar character, aluminum has no well-defined elastic limit. As compared to a copper wire, this is the same as a No. 6 B. & S. in weight, a No. 5 in breaking stress, a No. 3 in resistance, and a No. 1 in capacity and inductivity. It is the same size as No. 1, and its resistance an equivalent to No. 3. But while it has only the weight of a No. 6, it has the breakage strength of a No. 5; so as regards the necessary strength in a span, the wire is equal to a copper wire of about 70,000 pounds tensile strength, or a steel wire of about 60,000 pounds tensile strength, steel, of course, being lighter than copper.

Taking up the question of resistance, which is exceedingly important as indicating whether this wire of low tensile strength, which was strung in warm weather and had been subjected to extremely cold weather, had stretched, we found that the resistance of the line was 92 ohms, which is the resistance for 42.8 miles. The engineers gave the length of the line as 43½ miles, so the resistance was about seven-tenths of a mile shorter than the measured distance. I am strongly inclined to think that this is on account of the fact that the engineers have chained the whole distance by individual pole distances, attempting to set all the poles 132 feet apart, and that when they came to a place where it was impossible for them to set them exactly 132 feet apart, they selected a favorable location at about at about 132 feet from the last pole; so, we have some few long spans and some few short spans. Finally obtaining the entire distance, they counted the poles, and, multiplying by 132, obtained a distance of 43½ miles. Whatever may have been the reason for the difference between these measurements, that difference in size and direction indicates very clearly that there was no permanent elongation of the wire during the cold weather.

The next test is one referring almost entirely to the insulators and the condition of the wire during bad weather. Fortunately there was some extremely bad weather during the time the tests were made on this line. The insulation of one wire against the ground was found to vary from 160,000 ohms on a rainy day to 44 megohms on a clear day. In fact, on one day during a shower the line would vary in a couple of hours all the way from five or six megohms down to a quarter megohm, but, under no conditions falling below 160,000 ohms.



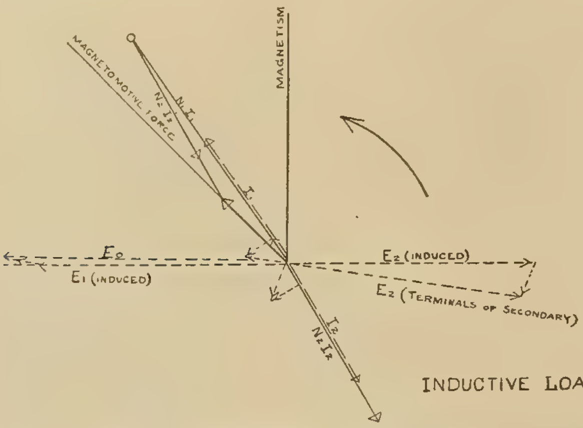
NON-INDUCTIVE LOAD

As regards capacity, the wires one and two tested alone called for $3\,{}^{23}/_{100}$ microfarads as calculated, and the measure was ${}^{35}/_{100}$. As regards the self-induction: ${}^{164}/_{1000}$ by calculation and ${}^{17}/_{100}$ by measurement.

---

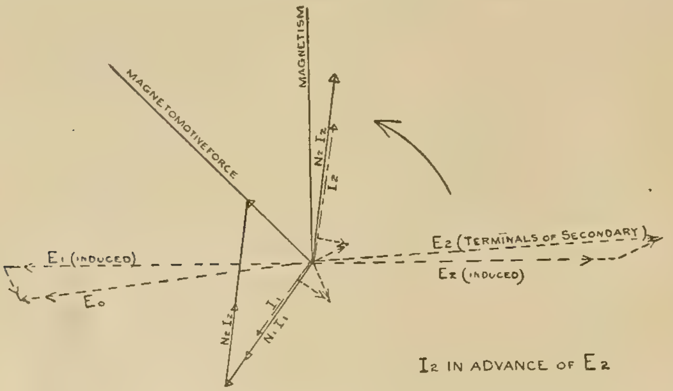
*A paper read before the Third Annual Convention of the Pacific Coast Electric Transmission Association, San Francisco, June 20-21, 1899.

There has been one point observed which has not anything to do with the line in a sense, but in another sense it has. And this was that the effect of the self-induction and capacity is to over-compound the step-up transformers. The step-up transformer ratio is 2300 to 25,000, and the step-down ratio 23,000 to 2200 with a possible variation of 200 volts in the regulator; but when current was put on the line without any load the voltage went entirely out of the range of the regulator which seemed impossible with 25,000 volts initial. In fact, the voltage at the step-down station showed 27,200 on the line. There is a rise of potential at the end of the line due to the capacity; but it is only 200 volts, and a rise of over 2000 was observed which was entirely due to the transformers. A calculation from the constants of the transformers accounts for all but 200 volts of the rise, and an error in calculating the angle of lead in the transformer may easily account for this.



INDUCTIVE LOAD

By calculation from the line constants it is seen that at no load on the step-down transformers the current leads the electromotive force by about 83 degrees. With 83 degrees lead the electromotive force at the secondaries of the step-up transformers ought to to be between 26,800 and 27,000 volts, and about 27,200 was observed. The explanation of the effect is quite simple, as may be seen by examination of the accompanying diagrams which present the three cases of non-inductive, inductive, and capacity loads with a constant primary terminal electromotive force. This effect is likely to appear in a very odd and more or less serious manner on long lines.



I_2 IN ADVANCE OF E_2

During these tests it was found that the capacity of the line varied materially with the state of the weather. The capacity between two wires would run all the way from three-tenths of a microfarad to .9 microfarad—three times its value—depending on whether it was raining or whether it had stopped raining, and so forth. If this occurs when the circuit is lightly loaded the current will swing clear around from lagging to leading and without a single change in the load, simply due to changes in the condition of the line, the electromotive force will go up and down. This is a condition to be provided for in our regulation, and calls for more regulation than has been commonly put in any of the sub-stations. The sub-station regulation is commonly figured out to be ample for the changes of load, but it follows that you must not only regulate for possible changes of load, but also for possible changes in the condition of the line which will throw the current from lagging to leading.

Gas

INDUSTRIAL GAS.—V.

BY FRANK H. BATES.

[THE HEMPLE APPARATUS—CONTINUED.]

THE explosion pipette consists of the thick-walled explosion-bulb *a*, Figure 15, and the level-bulb *b*, which are joined together by a wrapped piece of rubber tubing. At *c* two fine platinum wires are fused into the explosion pipette, the ends of the wires being about two millimeters (about $^1/_{16}$-inch) apart. At *d* is a glass stop-cock, and the pipette terminates in the capillary *e*, whose end is closed by a short piece of rubber tubing and a pinch-cock. Mercury is used as the confining liquid, this tending toward greater accuracy, there being no absorption, with mercury, of the carbon dioxide formed by the combustion, as is the case when the explosion is made over water, as with the Elliott apparatus.

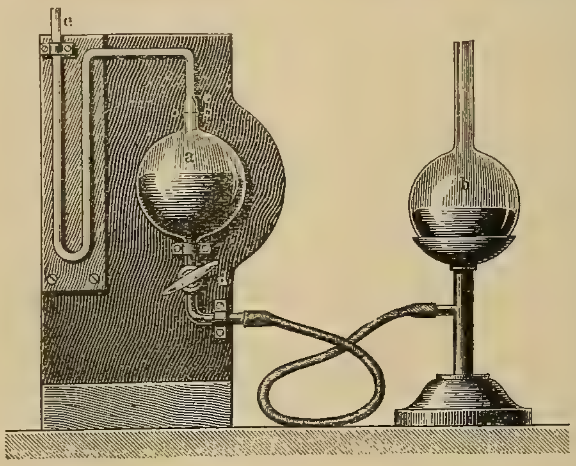


FIGURE 15.

The hydrogen generator. When one is called upon to analyze gas mixtures which do not contain sufficient combustible ingredients to make them explosive when mixed with oxygen or air, combustibility may be produced by adding pure hydrogen. This may be prepared in the special pipette, Figure 16. It is a compound absorption pipette which has two small bulbs in place of the first large bulb. Through the tube *g* a glass rod *h* is pushed up to the mouth of *e*. This rod is fastened tightly into *g* by means of a piece of rubber tube slipped over it, and it serves to hold pieces of chemically pure zinc in the bulb *e*.

To fill the pipette it is inverted, the glass rod is taken out, and the pieces of zinc are dropped into *e*. The pipette is then closed again, placed upright, and filled with diluted sulphuric acid (1:10) by means of a funnel with a very long tube attached to the capillary *i*. The hydrogen evolved during the filling frees the sulphuric acid from any absorbed air and at the same time fills the bulbs *b* and *c*. When 100 cubic centimeters of sulphuric acid have been brought into the pipette, some mercury is poured into *d*. The pipette is closed at *i* with a piece of rubber tubing and a pinch-cock. After a short time the hydrogen produced will drive back the acid so that the evolution ceases; the mercury prevents the entrance of air into the apparatus, and pure hydrogen is always ready. It is advisable to force a little water into the capillary tube *i* to prevent the entrance of air at this point. A few pieces of platinum foil may be put in with the zinc to increase the evolution of hydrogen.

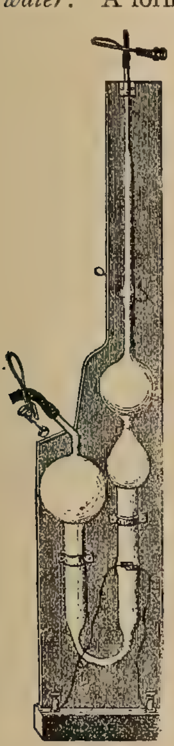


FIGURE 17.

Explosion pipette with electrodes for the decomposition of water. A form of explosion pipette within which hydrogen and oxygen are set free by the electrical decomposition of the water contained, is shown by Figure 17. This is applicable to analyses in which the error due to the explosion being made over water will not be of consequence. Two platinum electrodes are placed in the body of the pipette, and some little distance below the line of the surface of the water when the gas is contained. These are connected by wires to a battery. Having the gas within the pipette, the battery connection is made, causing a current to pass between the electrodes through the water, separating the latter into its elementary constituents, hydrogen and oxygen. A little practice will serve to guide one as to the amount of gas required. After disconnecting the battery, connection is made with the sparking wires and induction coil, causing a spark to pass through the gas mixture and thereby igniting the gases hydrogen and oxygen resulting from the decomposition of the water. The generations of heat and pressure in connection therewith is sufficient to ignite the gas itself, which explodes, giving a sharp tick. No account need be taken of the amount of hydrogen and oxygen formed by the decomposition of the water, since on burning they return to the former state in the same proportion.

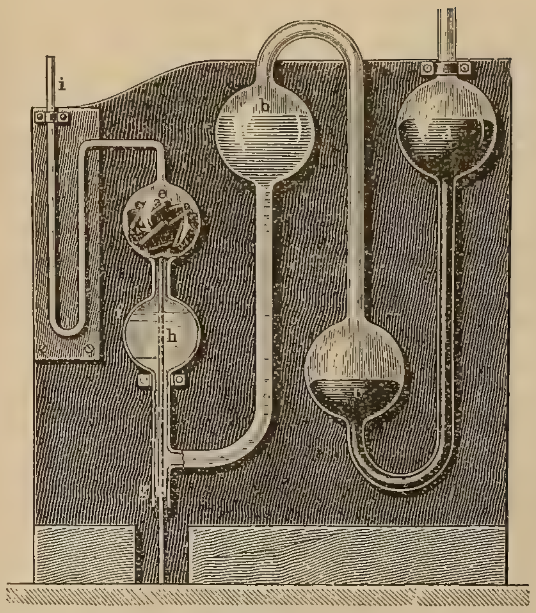


FIGURE 16.

The combustion of the methane and hydrogen in a gas mixture may be effected without explosion, by bringing the mixture in contact with a wire heated to redness in a pipette similar to that used for solid; see Figure 18. As this method offers no advantage and requires more time for operation than the explosion pipette, a detailed description will be omitted.

Operation of the Hemple Apparatus. In analyzing a mixture of gases with this apparatus the gas is successively passed through the several pipettes, simple and compound, containing the reagents, after which a portion of the gas residue (portion remaining after the absorptions are complete) may be passed into the explosion pipette and burned with oxygen to determine the hydrogen, methane, and nitrogen; or, for the latter operation may be substituted fractional combustion, in which case the hydrogen is first and separately removed by palladium, after which the methane is ascertained by use of the explosion pipette.

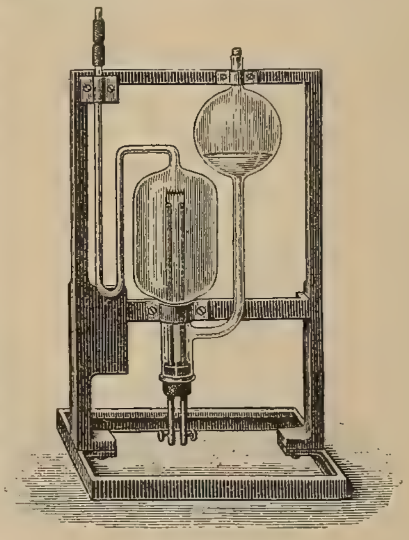


FIGURE 18.

Manipulation of the absorption pipette. The measuring burette *b*, Figure 19, must first be filled with water previously saturated with the gas under examination.

The contents of the simple pipettes must also be saturated with the gases but slightly soluble in them. The contents of the compound pipettes remain saturated for an indefinite time owing to the enclosure of a volume of gas between two bodies of liquid.

Draw into the measuring burette *b* 100 cubic centimeters of the gas to be analyzed, method for doing which has already been described.

Note that the reagents of each pipette are brought to a position close to the upper end of the white background, generally found attached to the frame of the pipette and in the rear of the capillary tube. It would be advisable to make a mark here (see E, Figure 19), that it may serve as a guide.

Connect the measuring burette *b* containing the 100 cubic centimeters of the gas sample, to the first pipette by means of the capillary tube F and rubber tubes *d* and *i*. In making up the connections with the capillary tube F, observe all the precautions heretofore cited, seeing that no air is permitted to remain between the pinch-cocks at *d* and *i*. It is advisable to use a pinch-cock at *i* as well as at *d*. To prevent the enclosing of air, fill the rubber tube *d* above the pinch-cock with water by means of a small dropping pipette; then insert the bent capillary which becomes filled with the water displaced. By now compressing that portion of the rubber tube *i* which is above the pinch-cock, and at the same time introducing the free end of the capillary, the connection may be made without enclosing air. If, however, by some slip, there should remain any air bubbles, they will appear at the beginning as the transfer of the gas is made. In event of their not exceeding a total length of, say, 10 millimeters (⅜-inch), in the upright capillary tube of the pipette, they may be disregarded, since that would be indicative of but 0.03 of a cubic centimeter or of an error of $^3/_{100}$ of one per cent.

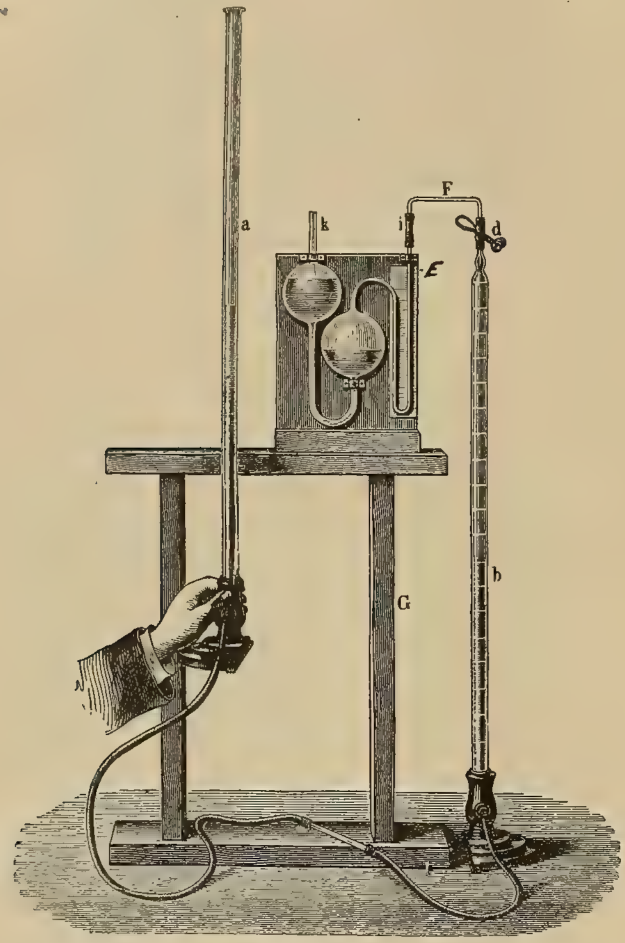


Figure 19.

With the reagent in pipette at the mark E, open the pinch-cocks at *d* and *i*, having previously raised the level-tube *a*. Force the gas into the pipette, allowing a little water to pass over into the pipette also, to make certain that the entire gas volume is transferred. Close the pinch-cocks at *i* and *d* and disconnect the measuring burette without removing the capillary F from the rubber tube connections above the pinch-cock at *i*. This leaves the pipette, containing the gas, free to agitate, rendering the absorption more rapid.

After allowing sufficient time to elapse to complete the absorption of this constituent of the gas mixture, the pipette is reconnected to the measuring burette, observing the same precautions as regards the enclosing of air, and the gas transferred by lowering the level-tube.

Bring the reagent to a position in the upright capillary corresponding to the mark E, when close pinch-cocks at *i* and *d*. Measure the volume of the gas in the measuring burette under atmospheric pressure by taking the reading with the level of the liquid in both level-tube and measuring burette at the same height.

Subtract this reading from the last, and in this case (the first absorption) the reading is 100 cubic centimeters, (the amount of the gas mixture taken for a sample) and the result will be the cubic centimeters of absorption or the percentage of the constituent absorbed. The percentage in each case will be slightly in excess of the true absorption, due to the gas remaining within the capillary F, but this is hardly to be considered of consequence, although allowance may be made by measuring the capacity of the bent capillary.

The manipulation of the compound pipettes is exactly similar, and of the pipettes for solids, the only difference lies in the case of the latter, in which the gas is exposed to the action of the solid reagent and requires no agitation as is best done to quicken the operation with a liquid reagent. By means of the Hemple pipettes, all waste is avoided, the reagents being used over and over again until exhausted.

After using, the pipettes are closed at the capillary end by the insertion of a short piece of glass rod in the rubber tube connection *i*, releasing the pinch-cock to prevent the rubber becoming set, and by closing the end of the glass tube *k* with a small cork.

It is advisable to keep an accurate account of the absorptions in cubic centimeters on the back of each pipette, so that, knowing their absorbing capacity, their full strength may be realized.

By not allowing any of the reagent to run over into the measuring burette, it will always remain clean; but should this occur, its simple construction permits of its being rinsed without trouble.

An analysis of coal gas will serve to illustrate the use of the various pipettes:

The measuring burette filled with water saturated with the gas under examination. 100 cubic centimeters of gas, measured under atmospheric pressure, admitted to the measuring burette.

The gas transferred from the measuring burette to the first pipette, a simple pipette containing potassium hydroxide. After thoroughly agitating the gas with the reagent, it was drawn back into the burette. After a lapse of three minutes to allow the burette walls to drain, the volume was measured and found to be 99.6 cubic centimeters. This, subtracted from 100 cubic centimeters, gave the percentage of carbon dioxide:

$$100 - 99.6 = 0.4, \text{ or } CO_2 = {}^4/_{10} \text{ of 1 per cent.}$$

Gas was passed into the second pipette, a special pipette containing bromine. After agitating, the gas was returned to the measuring burette, and then, previous to measuring, passed into the first or potassium hydroxide pipette, to remove the bromine vapors. Returned to measuring burette, and after a lapse of three minutes gas volume measured and found to be 95.3 cubic centimeters. This, subtracted from the last reading, 99.6, gave the percentage of fixed illuminants or heavy hydrocarbons:

$$99.6 - 95.3 = 4.3, \text{ or } C_2H_4 = 4.3 \text{ per cent.}$$

Instead of employing bromine, fuming sulphuric acid might have been used for the absorption of the heavy hydrocarbons.

The gas was passed into the third pipette, a compound pipette containing potassium pyrogallate. After agitating, the gas was returned to the measuring burette, and after a lapse of three minutes, gas volume measured and found to be 94.8 cubic centimeters. This, subtracted from the last reading, 95.3 cubic centimeters, gave the percentage of oxygen:

$$95.3 - 94.8 = 0.5, \text{ or } O = \tfrac{1}{2} \text{ of 1 per cent.}$$

Instead of employing potassium pyrogallate, phosphorus might have been used for the absorption of oxygen.

The gas was passed into the fourth pipette, a compound pipette containing ammoniacal cuprous chloride. After thoroughly agitating, and allowing to remain in contact with the reagent some three minutes, the gas was returned to the measuring burette, and after a lapse of three minutes gas volume measured, and found to 87.1 cubic centimeters. This, subtracted from the last reading, 94.8 cubic centimeters, gave the percentage of carbon monoxide:

$$94.8 - 87.1 = 7.7, \text{ or } CO = 7.7 \text{ per cent.}$$

Instead of employing ammoniacal cuprous chloride, cuprous chloride might have been used for the absorption of carbon monoxide, the former being required only when palladium is used for the absorption of hydrogen.

The 87.1 cubic centimeters of gas now remaining, termed the gas residue, transferred to the ammoniacal cuprous chloride pipette, which served simply as a holder. The measuring burette thoroughly rinsed out with hydrochloric acid and water and refilled with water saturated with air.

A little of the gas residue (from 12 to 20 cubic centimeters) was drawn into the measuring burette, and after a lapse of three minutes gas volume measured, and found to be 14.5 cubic centimeters. This was transferred to the explosion pipette, after having added some 15 cubic centimeters of air, and oxygen sufficient to bring the total volume up to 100 cubic centimeters. In making the transfer from the measuring burette, care was taken to have a little water pass over, and the rubber connecting piece was closed by a strong pinch-cock so as to confine the water within the pipette capillary. A piece of glass rod was also slipped into the open end of the rubber tube above the pinch-cock on the measuring burette being disconnected. The pipette was then thoroughly agitated to mix the gas, oxygen and air, the glass stop-cock closed, and by connecting to the induction coil and battery a spark was passed causing the mixture to explode. The glass stop-cock at once opened, and the gas transferred to the measuring burette, where, after a lapse of three minutes, gas volume was measured and found to be 76.05 cubic centimeters. This, subtracted from the total amount before the explosion, 100 cubic centimeters, the contraction:

$$100 - 76.05 = 23.95 \text{ cubic centimeters contraction.}$$

The gas was now transferred to the first pipette, containing potassium hydroxide, and, after agitation, returned to the measuring burette, where, after a lapse of three minutes, the gas volume was measured and found to be 70.15 cubic centimeters. This, subtracted from the former reading, 76.05 cubic centimeters, gave the carbon dioxide formed, which is equal to the methane:

$$76.05 - 70.15 = 5.90 \text{ cubic centimeters} = \text{methane.}$$

The gas was now transferred to the potassium pyrogallate pipette, to make certain there had been oxygen in excess,* and, after agitation, returned to the measuring burette. After a lapse of three minutes, the gas volume was measured and indicated an absorption of oxygen.

(Continuation in next number.)

Personal

J. N. Thomas, late of the Johnstown Steel Rail Company, and more recently of a well known electrical engineering office of New York City, is visiting relatives in Santa Rosa and will locate in California, if possible.

Chas. E. Sedgwick has resigned the assistant managership of the power and mining department of the San Francisco office of the General Electric Company, and has accepted the position of general manager of the Hilo Electric Light Company, Hilo, H. I.

E. M. Frazer, inventor of the Frazer electric elevator, the patent rights for which have been sold to the Otis Elevator Company, has gone to Chicago, having accepted the position of electrical superintendent for the Otis company in building Frazer elevators.

Norman Rowe, late of the engineering staff of the Westinghouse Electric and Manufacturing Company, Pittsburg, has been appointed electrical engineer of the San Francisco office of the Westinghouse company, taking the place of R. S. Masson who resigned some weeks since to accept the position of superintendent of the Independent Electric Light and Power Company, San Francisco, as previously announced.

The *American Electrician* in making an abstract of the description of Kootenay-Rossland transmission appearing in this publication, concludes by saying: "These facts are taken from an illustrated description of the system published with the usual clearness and thoroughness of illustration characteristic of *The Journal of Electricity*.

---

*This is a needless precaution in our case since oxygen was added in excess.

THE JOURNAL OF
ELECTRICITY, POWER AND GAS
Devoted to the Conversion, Transmission, and Distribution of Energy.

Conducted by GEO. P. LOW.

Official Organ of the Pacific Coast Electric Transmission Association.

Yearly subscription: Domestic, $1.00; Foreign, $1.50, postage paid.

Entered as second-class matter at the San Francisco Post Office, August 15, 1899.

Entered as *The Electrical Journal*, July, 1895. Entry changed to *The Journal of Electricity*, September, 1895.

Published monthly at 320 California Street, San Francisco, Cal.
Address remittances and communications to
315 CHERRY STREET, [Telephone, "Pine 76"] SAN FRANCISCO, CAL.

VOLUME VIII AUGUST, 1899 NUMBER 2

For Table of Contents see Page XI.

EDITORIAL.

THE ELECTRIC TRANSMISSION CONVENTION.

Prominent among the many profitable results of the recent convention of the Pacific Coast Electric Transmission Association, were the ideas brought about by the reading of papers upon the lines of rates for service and electric power in pumping, as well as those which followed Dr. Perrine's inquiry for expressions of opinion from practical men in regard to the insulation of pins, cross-arms and poles on high-tension lines. Equally instructive and interesting were the theoretical papers read on the calculation of transmission lines and on the regulation of alternating-current generators. In this issue appears the last of the papers read before the convention, while the final installment of their discussions will appear in the next number.

⁂

Without doubt the most valuable paper brought before the Association, and which, at the same time, is most pertinent to the majority of transmission managers who are looking towards pumping for irrigation purposes as a means of evening the load factor, was that by Mr. Lewis A. Hicks, C. E., on electrically-driven centrifugal pumps. Anyone who enters into this subject with the thoroughness with which Mr. Hicks has, is surprised at the paucity of information existing upon the subject, and his surprise grows to astonishment when he realizes that the views held on centrifugal pumping even five years ago are now of but historic interest. Indeed the last stepping stone in the literature on centrifugal pumping prior to that of Mr. Hicks' paper just referred to, was the essay by John Richards, M. E., published in 1894; and here the thought impresses one that the so-called "infancy" of electricity is prime manhood in comparison with the narrow advances that kindred sciences, though far older, have made during its comparatively limited existence. The fact is, that were problems concerning the design and operation of water wheels and centrifugal pumps, for instance, as carefully worked out as have been the designs of electrical machinery, the operation of water power and pumping plants would be simplified beyond measure. To illustrate: Is there a water wheel governor that gives regulation within that of a well-designed station transformer? Is there a water wheel in service that can approach a working efficiency within fifteen or twenty per cent. of that of an electric generator, or is there a centrifugal pump the efficiency of which can approach that of an electric motor by from thirty to forty per cent.?

It is probable that long before the United States Government or the state of California, or both, has gone through the tedious routine preparatory to the building of impounding reservoirs as prayed for by the mining, agricultural and transmission interests of the State, that the question of load factor in the majority of transmission plants will have been brought up to a high percentage in the majority of installations through the use of electric pumping service. Loads of this character are extremely flexible and any effort towards analyzing the losses in methods now in vogue, with a view to increasing efficiencies, is a stride towards the development of a line of business destined to be a safeguard in the economical administration of transmission plants. Mr. Hicks' paper is, therefore, much more than a technical discussion of the performances of centrifugal pumps; it is an exponent of the improvements that can be made in, and the profitable business that can be derived from, the operation of electrically-driven centrifugal pumps for irrigation and other purposes.

While the operation of these applications of pumping have heretofore been mainly confined to transmissions in the San Joaquin Valley, it is probable that the coming spring will witness the exertion of almost herculean efforts to unwater the Comstock mines by the application of electric power. This will mean the lifting of from seven to ten millions of gallons of water daily against heads varying from a few hundred to much more than a thousand feet under conditions of extreme dampness, high temperature, and, in some cases, narrow confinement. Here again may be repeated what has almost just been stated: the most serious problems to be encountered in the Comstock mines will be of mechanical and hydraulic rather than of electrical natures, for there is no question but that electricity will do its allotted work reliably and efficiently. The best form of pumps to be used, however, is not so easily determined as is the type of electric motor suitable for the service in direct connection for sinking purposes; and it now looks as though the next year or so would bring about new forms of sinking pumps, of compound centrifugal forms, or of adaptations of the Quimby principle in order that increased efficiency and simplicity may be attained through direct connection to the motive power. It is not to be questioned that the pursuit of investigations along these lines is of inestimable value to transmission interests.

⁂

While the subject of insulating pins and cross-arms on high-tension lines was under consideration, Mr. R. M.

Jones startled the convention by expressing the opinion to the effect that the use of potentials in excess of 50,000 volts for long transmissions would necessitate the placing of each transmission line, or rather wire upon a separate pole line before any assurance of reasonable immunity from insulation break-downs could be had. Though this suggestion seems a radical departure from existing practices, it is by no means without precedent in the annals of other branches of electrical industry; witness, for instance, the mighty protest that went up from tens of thousands of electrical concerns from the Atlantic to the Pacific at some of the revolutionizing requirements of the boards of fire underwriters. The utter annihilation of the incandescent electric lighting business was prophesied because of the then believed-to-be prohibitive cost of wiring thus entailed, but time has proven that the exactions were those of wisdom and prudence. So, too, may the hundred-mile-or-more transmission find commercial feasibility through the use of extremely high potentials carried on single-wire pole lines erected in accordance with Mr. Jones' suggestion. The dismal failure of the 40,000-volt line in Utah came like a shock because of the previously glowing accounts of it which had been received; but now that the truth is prevailing, it seems patent more than ever that the use of such a potential in a mountainous country is impossible with the ordinary form of construction installed. It will be said that the construction of the line referred to was by no means an ordinary one; that it was far below the ordinary, and that it was most wretched. Even so, and considering also the fact that the neutral of the line was grounded, the fact of the repeated burning-out of cross-arms and poles indicates the necessity for some radical change in the form of construction if such voltages are to be used.

As the lengths of transmission and the potentials of line currents go onward and upward, the questions of line insulation grow of ever increasing importance. The business public will not accept financial risks under any condition other than that where every assurance has been made doubly sure, else why should the relations between the mortgagor and the mortgagee, for instance, be so clearly defined in business ethics? On the same reasoning, it does not appear to be wise for the transmission engineer to entrust the insulation of his line, which is a vital question from every standpoint, to the insulator alone, when the insulation of the insulator may be strongly reinforced by insulating the pin and cross-arm to the highest possible degree. Granted that the insulator is reliable, it can then only be said that if the engineer has further increased its reliability by insulating pins and cross-arms, he has done no more than that which commercial prudence dictates in the demand that every assurance shall be doubly sure.

⁂

The title of Mr. Martin's paper—"Electric Lighting versus Gas"—suggested a revival of the old feud between the two modes of illumination that are foremost in public favor, but it is positively refreshing to note the spirit of fairness that pervades it. It is not necessary to refer to the discussion, however, to know that his enlightened ideas on the subject are not entirely those of the electrical community, and it is a source of regret to realize that—to borrow from the paper—"blind prejudice" is far from being unknown to the minds of many managers of both gas and electric plants. These columns have repeatedly emphasized the conviction—and they do so again at the risk of redundancy—that the antagonism between gas and electricity as a means for serving the public with light and power, is altogether unnatural, unwarranted, and unprofitable, and an awakening to this belief by both interests would probably be more beneficial to their earning capacities as would the elimination of their bonded indebtedness. The enormous commercial interests involved in the conversion, transmission and distribution of energy, whether for purposes of light, heat or power, or whether by water or steam power, gas, compressed air or electricity, are all most intimately related, and have common cause to which unprejudiced and unswerving devotion will advance to an indefinite degree for the general good.

⁂

The old question of meter rates, and its long line of attendant *et ceteras*, was revived by the reading of Mr. Martin's paper, but interest therein would probably not have advanced beyond the commonplace had not Mr. Hutton opened an original line of reasoning by suggesting a practical means for the determination of equitable rates. Mr. Hutton's paper is pregnant with matured conclusions upon a subject of vital interest to every plant of whatever nature that has to do with obstinate load factors, and as such it can hardly fail to become recognized as among the classics of central station literature.

⁂

If copper producers and wire merchants had taken second thought and had realized that the day has at last arrived when it is no longer necessary to use copper for electric transmission lines, it is possible that the price of copper would not be quite so high as it is at present. It was singularly opportune for manufacturers of aluminum that the price of copper went skyward just as they had perfected processes for the production of pure aluminum in unlimited quantities. The result has been that the inflation in the price of copper has done infinitely more toward the introduction and use of aluminum in line work than it would have been possible to have accomplished in a decade of education through the pursuit of the ordinary means of hum-drum talk by well-drilled selling agents. Dr. Perrine's paper afforded the means for focussing the attention of the Transmission Association upon the use of aluminum for transmission purposes. Much valuable information concerning the use of that metal for electrical conductors was given by Mr. Lee, and Prof. Cory added an outline of tests which have been under way at the mechanical laboratory of the University of California—all distinctly favorable to aluminum. Thus, one by one, are being swept away the phantom arraignments alleging the unfitness of aluminum for electrical purposes. Transmission interests have cause for jubilation that they are now disenthralled from complete bondage to the copper kings, for which thanks should be given largely to the cupidity of the copper kings themselves.

⁂

The very practical and concise paper by Mr. Van Norden brought out two interesting themes for discussion. First, electromotive forces as high as 16,000 volts are far more tractable than was formerly supposed; witness their confinement by telegraph insulators and paraffined pins through winds and rains as Mr. Van Norden relates. This, however, is according to the experience of the Pomona plant (though there the potential is but 10,000) where for two or three years no effort has been made to replace broken or shot-off insulators unless the insulator is entirely demolished and the line drops to the cross-arm. The result is that a motley assortment of apparently wrecked glass insulators are still in service, but their utility nevertheless seems to be evidenced by the fact that they still prevent the occurrence of appreciable leakage. For this, however, thanks be given to the climate of southern California alone. It is not contended for a moment that carelessness in replacing broken insulators, or in using telegraph insulators even temporarily, is to be condoned at any ordinary time. Meschech, Shadrach and Abednego are also reputed to have walked through a fiery furnace without singeing a hair, but an attempt to do such a thing to day would be considered an evidence of idiocy by even the blindest fanatic. It is not supposable that transmission engineers are going to tolerate the continuance of broken insulators in service or consent to the reduction of the size of glass insulators, even though the Pomona line runs on petticoatless glass stumps, and even though the Central California line found that telegraph insulators proved serviceable during a famine in standard types of high-tension insulators.

⁂

Secondly, Mr. Van Norden has found from experience that the synchronizing of generators in widely separated stations is easily accomplished; in fact, to quote his paper: "The distance seems to have a cushioning effect and it is not by any means so necessary to have the generators so near in synchronism when thrown together as when side by side." Mr. Jones' remarks gave this opinion a strong endorsement in citing the experience of the Big Cottonwood and Pioneer stations in Utah, which are synchronized with perfect ease though some fifty miles apart. When to this is added the remarkable combinations of steam, water power, street railway, Edison three-wire, single-phase alternating, and multiphase transmission plants in daily operation in southern California, part of which were described in detail in the San Gabriel edition of the JOURNAL, it will be seen that the synchronizing of practically any portion or portions of modern electrical machinery is no longer a subject to cause the slightest hesitancy in the plans of electrical engineers.

⁂

Prof. Cory's paper on the regulation of alternating-current generators is given as the leading article in this issue, and its perusal will show that its writer has made a very clear and comprehensive exposition of the principles which underlie that which is ordinarily considered to be a complex subject. Space forbids a detailed consideration of the questions involved under this heading, albeit they are of the utmost importance in electrical transmission work, and it is a misfortune that the literature available upon the subject is so almost incomprehensible to the ordinary reader. Prof. Cory's paper is, however, exactly in the right direction, and it is fitting to express the hope that the initiative he has so ably taken may soon be followed by other productions which will clear the minds of the electrical masses of much of the doubt now existing concerning the inherent regulating qualities of, for instance, revolving armature, revolving field, and inductor types of generators under the trying conditions imposed in long transmissions for heavily-fluctuating power service. Upon this point hinges the perhaps bitterest contentions among advocates of the different types of polyphase generators, and the sooner the atmosphere is cleared the better for all.

⁂

As to the Association itself, too much stress cannot be laid upon the words ot the new president, Pce. A Poniatowski, in closing the session, for they bespeak a thorough cognizance of its aims and needs. While the Association is flourishing, it must be confessed that there is some dissatisfaction with the rule that has been in vogue of having only annual meetings. President Poniatowski leads those who are distinctly opposed to the idea that all there is of mutual interests to be said concerning transmission matters can be said at a meeting to be held once a year. Indeed, there is no other field wherein the necessity for frequent intercourse between members is more necessary than in that of the electrical transmission of power. Other lines of industry are older and their methods have settled down to well-defined practices, and while the latter is true to a great extent in electrical transmission work, there yet remains an abundance of material to be threshed out in the light of the experiences of different installations under widely different skies. As yet no definite plan has been formulated for more frequent meetings, but it is probable that the holding of quarterly meetings will be determined upon, the first of which may occur in October. As suggested in the President's remarks, the papers to be presented at meetings hereafter will be printed at least a fortnight beforehand and submitted to members that they may be prepared to discuss the subject matter intelligently, after having had the opportunity to digest the papers under discussion.

The Transmission Association is thriving as no other organization of the kind on the Pacific Coast has done; it is working in virgin soil under especially favorable conditions, and the wealth of experience of its members constitutes information that is sought for by electrical engineers the world over. Nature has so endowed its surroundings that the Association has a mission to perform for electrical engineering, and that it will do it well is not to be doubted.

Live Steam and the *Engineers' Magazine* have consolidated and now appear as *Steam Engineering*—a very worthy publication.

The Third Annual Transmission Convention.

Official Report of the Discussions which Followed the Reading of the Papers at the Association Meeting Held in San Francisco, June 20-21, 1899.

PRESIDENT W. Frank Pierce called the Third Annual Convention of the Pacific Coast Electric Transmission Association together at the Cliff House, San Francisco, on the morning of June 20th last, as previously announced in these columns, and, after a few graceful remarks pertinently referring to the prosperous condition of the Association, and the powerful influences for good which it is exerting, immediately proceeded to the transaction of the business at hand, the first of which was the delivery of a paper by F. A. C. Perrine, D. Sc., on "Tests and Calculations for a Forty-Mile Aluminum Wire Transmission Line." This paper is reproduced on page 41 of this issue.

Prof. Cory: Mr. President, I would like to ask one question of Prof. Perrine. By what formula did you compute the capacity of your line?

Prof. Perrine: I computed it in two ways: by the simple formula, and then I worked it out in the most complicated Heaviside method, and I did not find the complicated method gave any better results than the simple one. I came to the conclusion that the ordinary equation for the capacity of two parallel conductors in air, gave results within the limit of the errors of the instruments, and I do not see any use going into it further.

Prof. Cory: These computed results then which you give were obtained by the use of this formula

$$C = \frac{1.11 \times 10^{-6}\ k\,l}{4 \log_e \frac{d}{r}}$$

Where k is specific inductive capacity (for air, unity).
l is length of conductor in centimeters.
d is the distance between conductors in centimeters.
r is the radius of conductor in centimeters.
C is the capacity in microfarads.

The Chairman: Gentlemen, have you anything further to submit on this subject which we have had before us for discussion?

Mr. Gilbert: I would suggest we might hear something in the abstract upon aluminum. We have representatives of the aluminum company here, and they might be able to offer something.

The Chairman: Mr. Lee, will you give us some information on the subject?

Mr. Lee: In the abstract there is very little to be said, and I think most of the points which have been brought out, by Dr. Perrine in particular, were a good deal more interesting than those in the abstract would be. One of the most striking stories that have been circulated is one that was published in the San Francisco papers some months ago, and at the time I was not very certain about it; I thought it might possibly be true, and I therefore did not say anything until I could ascertain what the experience really had been. It seemed that somebody from the Arizona copper district came up here—incidentally he was very much interested in copper—and he made the broad statement to some reporters on the newspapers that aluminum was a failure. He made a very flat statement, and he based it, he said, not on any theoretical conditions, but on an absolute experience of the Pennsylvania Railroad that the life of aluminum wire was six months or thereabouts; of course, under certain favorable conditions it might last seven, but at that time that was about the limit of its life. Exactly what happened to it he did not state, but I presume it was that the wires disintegrated. The case he took in point was that of the Pennsylvania Railroad. I communicated with our factory as to whether it had been a success; they replied that the superintendent of telegraph had ordered a good deal more aluminum and that they were getting it out as fast as they could.

Prof. Perrine states that the comparative conductivity is sixty per cent., and in practice we use sixty per cent. greater cross-section. From the tables that are given of copper we find by reference to the cross-sections, that by using wire two sizes larger we get practically the same conditions as regards conductivity; sometimes a little in excess and sometimes a little less. We have adopted this rule for convenience and so as to conform to the Standard wire gage. Nearly all the tables in existence are those of B. & S. copper wire, giving the data on copper wire, and to avail ourselves of those tables we have laid down that rule. As regards the question of weight we find that it is practically 48 per cent. of that of copper of equal conductivity. That is to say, if you had a certain span of wire, copper, of given conductivity, and weighing 100 pounds to the span, a span of aluminum of equal conductivity and length would weigh 48 pounds.

Aluminum, of course, is rather susceptible to alkalies, but is not affected to any great extent by acids; and the Sunset Telephone Company, which has strung an experimental line, I believe somewhere out in this direction, were satisfied with aluminum and have begun to use the wire.

The question of price: It is considerably cheaper than copper. I don't know exactly what the price of copper is, but I think in the neighborhood of 21 cents today, and aluminum is in the neighborhood of 33 cents, and at these prices, taking into consideration the fact that you only have 48 per cent. of the weight of copper for a given conductivity, we can put up aluminum for a price that is about equivalent to copper at 16 cents per pound; so that there is a decided advantage in the matter of price in favor of aluminum.

For connecting aluminum wire we have a very simple joint which was invented, I believe, by Mr. A. M. Hunt of this city some years ago. It is merely a flattened aluminum tube, the two wires are laid side by side and twisted up in the same way the McIntyre joint is made. The McIntyre joint differs from the aluminum joint in that there are two tubes brazed together, but I presume at the time the McIntyre joint was devised the patentees were not familiar with the way in which a single tube would work. On the Standard company's circuit between Blue Lakes City and Stockton where the tubes were crimped before they were twisted, the tube falls right in between the two wires, and when a joint of this character is cut or sawn in two and the ends polished, it is very difficult to notice the line indicating the joint between the tube and the wire. Some tests made at the Pittsburg Reduction Company's factories show that after some of these joints had been immersed for over 36 hours in a strong alkali solution, they still had a higher conductivity than the wires themselves, so that, commercially, the joint is a good one and eminently satisfactory. Some engineers were afraid moisture might get in and tend to impair the conductivity of the joints, and for that purpose have painted the ends of their joints with some elastic varnish, but it was as an additional safeguard, and I think practically the conditions of the aluminum joint are the same as the McIntyre joint.

Dr. Van Norden: What is the relative cost of stringing the wires?

Mr. Lee: There is no reason why it should be more and a great many reasons why it should be less in cost than copper, because with the same conductivity you have less than half the weight to handle. There is every reason to suppose, if there is any difference, it is in favor of aluminum.

Mr. Martin: As far as my experience is concerned, there is no difference in the cost of construction, as the linemen will not climb any more poles in a day, nor any less, and they will tie just as many wires.

Mr. Masson: We were told here some time ago about a man who went up a pole to string aluminum, and, speaking jocularly, found by his thermometer it was 72 and by his table found three spots on the red, or something like that, and then he pulled up the span. [Laughter.]

Dr. Perrine: I am afraid I am responsible for that I have always held, and I think in common with the engineers of the American Bell Telephone Company in the East, that all wire ought to be strung in accordance with the temperatures; and accordingly, when the Standard line was strung, I gave strict instructions to the men that they should tack to their wire wagon a thermometer, and that they should pay attention to a table of deflection, which was similar to a table of deflections I had prepared when we were intending to use copper, because I have seen many copper lines ruined by tight stringing without reference to temperature — particularly here in the West. Copper is just as devoid of elastic limit as aluminum, and if you string your copper in warm weather it is going to stretch in cold weather and you are going to have an increased length at an increased resistance. The Chicago-New York line was all strung with thermometers in the buttonholes of the linemen, and they do all of their good work in the East in that way. That is the whole origin of this thermometer business in connection with the Standard line. I would have used a thermometer whether it had been copper or aluminum. It is more necessary for this reason: You cannot find a lineman who has had the same amount of experience with aluminum as with copper. If I had a lineman who had strung as much aluminum wire as some telephone men have strung copper wire, I would consider that that man's judgment could be relied on. But consider our line: This line was No. 1 wire, and a No. 1 copper wire is very frequently strung with a team of horses on the ground. In this case, two men, or at most three men, on the ground could have over-strung the aluminum wire, and in stringing we had five linemen tying, two jointing, and four on the ground tackle.

Prof. Cory: Some tests on the aluminum wire used on the Blue Lakes-Stockton transmission line were made in the mechanical laboratory of the University of California recently, and it was shown there that the tensile strength of the wire was approximately 20,000 pounds per square inch. One test that was interesting was to determine the strength of the joints. One or two joints were tested, the joints having been made by the linemen on the Stockton line. It was found in every case that the wire itself was pulled in two before the joint gave way, showing that at least with joints very recently made, the strength is greater than that of the wire. Of course it should be remembered that this wire had not even been strung, so that it had not been subjected to any mechanical strain or continued vibration. Some tests were also made in the electrical laborotory upon the conductivity of the same wire, and the results in general agreed very closely with the tables of the aluminum company. Here again the joints made in the wire showed a less resistance than the main wire itself. What effect an alkali would have upon such joints of course could not be determined.

It is proposed, very soon, at the University, to make more careful tests upon aluminum wire, inasmuch as we will have one or two of such lines in operation within a short time. After these lines have been up for a few months, some more conclusive results will be obtained regarding the temperature coefficient and the effects of connections into copper or brass terminals. Even in the laboratory the remarkable lightness of the wire has shown its advantages, and but one difficulty was encountered in the tests we made, and that was, to handle the wire carefully.

Dr. Van Norden read a paper prepared by his son, Rudolph Van Norden, and reprinted on page 14 of the July number of the Journal.

The Chairman: I understand that Mr. Jones has had considerable experience in the paralleling of widely separated stations. May we hear from him?

Mr. Jones: The Big Cottonwood station has a 2000-kilowatt equipment, and the Pioneer has practically 3000 kilowatts. They are 52 miles apart, have been running parallel for a year and a half I think, and no difficulty has been found in synchronizing and running the stations together except at the times line troubles occur when they are running in synchronism. The first application was at the time that the Cottonwood station had been in operation for about four months continuously without opportunity for cleaning up, and during one Sunday afternoon the Pioneer company took the load and permitted the Big Cottonwood plant to shut down. There had been a difficulty anticipated in synchronizing, and during the shut-down the station attendants changed the leads coming in from, I might say, the primary side of the Big Cottonwood, and started up the three generators, synchronized them together with the main line, and then synchronized that station with the Pioneer and the city station. The Pioneer did not know this was going to occur at all, there had been such a difference of opinion about it; they had a reckless man and he took it on his own hands to do it. After that the synchronizing was done, I think at all times at that station, instead of at the central point, Queen City. There has been no difficulty in that line whatever.

Mr. John Martin then read a paper on "Electric Lighting versus Gas," and reprinted on page 11 of the July number of the Journal.

Dr. Van Norden: I don't think sufficient emphasis has been put upon the deterioration of the atmosphere in the room in the use of Welsbach burners. My attention was called to this when I went to Sacramento, and I was told this defect would prevent the success of that burner in that city. The mantel is composed of a substance which in the very great heat volatilizes and is poisonous, and as the burner requires not only oxygen, but a very large portion of air in the room in addition, which is mingled with the gas, so there is a double consumption of the air in the room—a double production of carbon bioxide. The effect upon a room with the windows and doors closed is extremely vitiating, far more so than with ordinary gas-jets. It is impossible for persons to use those burners with closed doors and windows and preserve health; and while persons using them do not discover it at once they find they do not enjoy life. I think the reason they have that feeling is largely that there is an effect upon them of which they become in time not exactly conscious, but sub-conscious. They know there is something wrong about that burner, and we find as a matter of fact that nearly all the Welsbach burners in Sacramento have been given up. I think in the long run they are sure to be thrown out universally as disagreeable, and the light they give, though undoubtedly economical, is extremely dangerous to health.

We have found from our experience that extravagance in the use of lights on the flat rates lessens. At first the family revels in the light and all the burners are turned on, but after awhile they turn them off very much as they do gas; they don't care for the glare. With regard to the rates, we find that the average rate in Sacramento is for residences about 19 cents per month—a little less than that; that the average for business places, saloons, etc., is probably not over 40 cents, and yet it is a good business—at least our company has found it so. There is a very extensive consumption of the electric current because of the low rates, and it seems there is no limit to the business. I know when the Folsom company went into Sacramento their expectation was that a few thousand lights might be taken; I think we have very nearly 40,000 now in the city, and I see no reason why we should not have 80,000. I am quite confident another thousand horsepower will be put in Sacramento just on the incandescent lights. There is a large field for the use of gas in the heating of stoves and so on, and perhaps in some cases in gas engines; but gas as an illuminant is not to be feared—at least if we can do business on the rate we have in Sacramento.

Mr. Martin: Being interested in a gas company, I tried to make my paper as unbiased as possible, because I have attended the meetings of the Pacific Coast Gas Association and also the Transmission Association, and I find the personnel of each association carried away with the idea that they were the only people on earth. Now, with all due respect to Dr. Van Norden, you will find, in competition with gas a gas plant administered on pure business lines and also progressive and active, that they will have a fair clientage for the use of gas for illumination, and largely for the purposes of heating. There are some people who object to the flickering of electric light, which happens occasionally with machines. There are some people who object to the white incandescence of the ordinary incandescent lamp, preferring the soft yellow light from a gas tip. They appreciate that in sitting in a room for a number of hours the air becomes vitiated; at the same time they are willing to put up with that for the other conveniences they receive. But that which appeals to most people is their pocketbook. After you get them in the habit of using one kind of illuminant they will not change it unless they are influenced by the price. The prices cited by Dr. Van Norden are much lower than the prices cited in my paper which were taken as an average of the prices in California. I assume 25 cents for residences and 80 cents for business houses, which is just a little under the average charge by the water power plants in California. Our experience in Grass Valley and Nevada City where we have been operating three and a half years, is such that the illumination of those two towns has increased almost 700 per cent.; that is, the amount of the candlepower illumination is over 700 per cent. greater than it was four years ago. We know that because we acquired the interests of the existing companies at that time, and our increase in total output has been 700 per cent. At my own house we have both gas and electricity, and without any education on my part I find that my electric bills are much larger than my gas bills, the gas being used almost entirely for heating and is very seldom burned for illuminating purposes.

Mr. Beale: The company of which I have the management for the time being sells its current at wholesale, and the gas company is going out of business as a gas company. One thing that has not been touched on, and which comes into very marked notice when you think of it a little, is the climatic condition in San Francisco. I would not be surprised at all at many people continuing the use of gas in San Francisco for the reason that the lighting of the gas in the chill hours of the evening does raise the temperature of the room. That would not be an advantage in Bakersfield or Sacramento. I don't think that anything ought to be sold at a flat rate, no matter whether it is gas or potatoes, or anything. I think the whole system is wrong. Give a man a fair measure for a fair price is the only really sensible way of selling anything, according to my standpoint, no matter what it is.

Pce. Poniatowski: What has the public to say about that? Do they like flat rates or measurement?

Mr. Martin: I presume that question is for me. I will make a homely illustration and let the managers understand why I favor flat rates. I will first give it from the consumer's standpoint, and then from the standpoint of the manager of a plant. The consumer analyzes your question about as follows: Having been consuming gas, which is a comparatively known quantity to him, (and forgetting that he in the past has complained about the excessive gas bills which he could not understand) you approach him for business, and the only way you can appeal to him—particularly in a small city—is to ask him how many lights he will average throughout the year, how many incandescent lamps will take its place, and at the rates which we have established in this community will the cost of it be greater or less, and in so determining take the total of his last twelve months' gas bill. They usually find that while in the summer time their gas bill may be a dollar and a half or two dollars per month for a small family, it will range from eight to twelve dollars per month in winter; whereas with the incandescent illumination at 25 cents per lamp per month he installs seven, ten or twelve lamps in his house, it will amount to $2.50 or $3.00 per month. He becomes favored with the idea and installs eight or ten lights; he visits his neighbor, who has twenty lights in his house and the house is well lighted; he goes home to his place and finds only one burner in the room, and finds it rather dark and gloomy; he thinks the matter over and, as a result, he puts in four or five lights more. That has been our experience in small towns. Now, from the standpoint of the manager of the plant: The average water power plant in this State is in search of business on the basis of horsepower. If we can obtain 75 or 80 per cent. of the price we are willing to sell our power for for 24 hours' service, and always have it available for at least twelve hours to dispose of, it certainly becomes a good financial business proposition.

There is one difference between this and and other lines of business, namely: your fixed charges are constant, assuming your installation to be based on a continual supply of water; you install 1000 or 1500 or more horsepower; your employees and your station operating expenses are constant at all times; the only additional expense on account of increased business would be the running of a few additional lines, a few more poles, and a few more transformers, which is a very small percentage of the total investment. Now, until you reach a point where the earnings of the plant are able to pay your fixed charges, you are always suffering a loss; but immediately you pass that line 95 per cent. of your earnings are a a profit. To that extent it differs from any other business I know of. Those are the reasons I maintain a sale of lights on flat rates are a benefit to the consumer, because he can use the light as he pleases without anxiety as to extra cost, and it is no detriment to the company because it is realizing an extremely good price per horsepower for its current.

Prof. Cory: I cannot take the side of either Mr. Beale or Mr. Martin on flat rates, because I have had no direct interest in any company furnishing lights; but I can say this: The University of California has a plant which supplies, I believe, fourteen different departments with electric energy. During the day the energy is used in the different buildings by many different people; and at night the energy is used almost entirely in lighting the library. We found, however, that the University people were very careless in going away from the buildings and leaving the switches closed, with the result that the electrical energy was wasted during the night in rheostats, lamps, etc., and we would have perhaps five horsepower going to waste in this manner from six o'clock in the evening until 1:30 in the morning. That was a serious matter, from the coal-bill standpoint; so we decided, about a year ago, to put in meters in the various departments. Of course, no one individual is financially responsible, but the department budgets *are* responsible: and we found from the first that we were saving something like $35 a month on account of the meters. The total cost of these did not exceed $300. This led me to believe that what Mr. Beale has said is true: that a just, fair measure and a fair return is what ought reasonably to be expected on each side.

There is another point in connection with the flat rate versus the meter rate, and that is the incandescent lamp. There are incandescent lamps and *incandescent lamps*. Some lamps are very efficient with comparatively very short life; and other lamps are perhaps not so efficient and are longer-lived. In connection with the lighting of the University library—we use about 500 lights of 16 candlepower each—we find we are saving about $150 a year by using 3.1-watt lamps rather than 3.6-watt lamps. In other words, from our standpoint it is cheaper to burn up lamps than to burn coal. I do not think we would know about those things if it were not for the meters.

THE CHAIRMAN: Mr. Heger, will you give us your experience?

MR. HEGER: I have little or no experience on that subject, but I was interested in small stations in early days before meters were used to any great extent, and found out then that people wanted a very inefficient light that would last forever, and we found that would cut into our coal bill in such a manner that we concluded to furnish consumers with high efficiency lamps in order to keep the lamps at their actual efficiency all the time instead of letting them burn lamps that would last forever at our expense.

THE CHAIRMAN: What bearing will that have on the present construction of lamps? Has there been any modification of construction by which that is avoided?

MR. HEGER: I think it is conceded all around that it is better to use a higher efficiency lamp.

PROF. CORY: Not with a meter rate. If I owned an electric lighting station and was selling energy at so much per kilowatt-hour, I would want my customers to burn just as inefficient lamps as I could get them to use.

MR. HEGER: But you would lose your customers very quickly.

PROF. CORY: The trouble is, the customers don't know these things.

MR. MASSON: In considering this subject you cannot escape the source of power. If you are considering the question you have to consider where you get your power. As I understand Mr. Martin's idea, if you have a meter proposition and a water power plant on which a lot of miscellaneous customers are working, it is very well known that between seven and eight o'clock in the evening, if it is dark, (or between eight and nine) everybody is going to have his lights on, and that the peak of that plant will be a certain definite amount no matter whether you have a meter rate or a flat rate. Some people may turn off some of their lights, but taking a certain peak load, you can get more money from a man if you will let him continue to burn his lamps all night than you can if he can only burn them for one hour when he uses the meter. If the peak is the important feature and you allow him to continue the use of that lamp all night he will give you more money, and if you can get more money per kilowatt peak load by letting him burn his lamps all night and all day, I think that would be the best way to sell it. On a steam plant you don't care much what the peak is as long as you can keep down the total coal bill, and keep inside the plant capacity; so that whenever a plant is based on a supply of fuel or a supply of water that can be saved over until the next day, the meter is the right thing; but in all plants where the flow of water is not important except as a peak, the flat rate seems to be the best thing.

MR. MARTIN: I would like to know what difference it makes to a plant operating 2000 horsepower at $5.00 per horsepower per month, with a revenue of $10,000, or receiving $10,000 for flat rates for lighting, assuming the fixed charges and operating expenses were the same? I cannot see the difference.

DR. PERRINE: It seems to me the difference lies in the fact Mr. Martin forgets that "electricity is in its infancy," [laughter] and the history of this whole meter business throughout the country has been that when the plants were installed all they cared to sell was up to their peak load, and after a few years they began to care to cover the territory. I have been to a great many meetings of the National Electric Light Association, and I was there particularly when the plants were changing from flat rates to meter rates, and I found a strong argument in favor of the meters was that a certain original investment would handle a larger territory with meters than without meters, and that is the point which Mr. Martin neglects. It is not solely how large is your peak load and, consequently, how many dollars you are getting from it, but it is also how large a territory you are handling and how many customers you serve. So long as your water power is greatly in excess of the demands of the territory, perhaps the condition Mr. Martin speaks of is true, but inside of five years from now the probabilities are that a great many plants in California which now have water power to waste and are unloaded, will be fully loaded and hunting for more water power.

MR. BEALE: A thing to be desired is a load as near a hundred per cent. of the installatien as you can get. If a water power plant should be so fortunate as to have a great big meter load during the day, carrying it up to say, 66⅔ per cent. of its peak limit for an average load during the light hours of the day, there might be considerable force in the position Mr. Martin takes. I don't know of any such plant. I was talking on this subject just a day or two ago with Mr. A. M. Hunt, who has been making considerable research in this direction recently, and he tells me he has communications that indicate to him that the 24-hour average load some of the London plants run for lighting alone is a little over ten per cent. of the peak limit. Of course those are not water power plants. If these same plants had a good large stationary meter load you can readily see what the effect would be upon the installation, and a very short calculation would show you what your horsepower installed would be as compared with you horsepower revenue on a 24-hour basis. There is no question that after a while the people get over their playful extravagance when the door is thrown wide open to them, just as children will dive in when the pantry is open; but when left open for a month they get over it, and the extravagance will drop and they will not use current even on a flat rate to so large an extent as they would at first when having the opportunity of doing so. But the real point is, the giving of a definite thing out for a definite sum received. The customer who buys largely is entitled to a wholesale rate, but he is not entitled to any more units at the rate you give him than the man who buys a small quantity. The proper thing is, a yard of goods is bought for a shilling, and if you sell 1000 yards perhaps you can give a better rate.

The whole matter of flat rates has grown out of the proposition of introducing it into houses equipped for gas and not equipped for electricity. In some places the opposition lighting companies have begged the privilege of wiring the houses for nothing. We know that is ridiculous. We ought to give a better and cheaper service than the gas company can give—if we can—but in justice to our own interest it is the duty of every plant, of every institution organized as gas and electric light companies are, and as all quasi-public corporations are, to give to the community the cheapest service they can, based upon the amount of capital invested. There are none of us who would care to sell anything we have other than electricity, at a flat rate. I have not any data on this except that which was brought to me by a customer who buys his electricity at a wholesale rate and sells it flat. I know his experience is foreign and radically opposed to what I consider a primary business principle; namely, a reasonable exchange of quantities.

THE CHAIRMAN: Then the installation of storage batteries would be an important factor in your manner of doing business—charging by meter rate?

MR. BEALE: Not so much so as in a flat rate. I have had no experience with storage batteries, and we are so situated that storage batteries do not cut much figure to us. We are in the situation that Mr. Martin is: we have more power than we have market for, and when the peak load comes on we simply pick it up and carry it and still have a margin left. We notice very markedly the difference between the peak load when the light comes on and the steady meter load which we have for twenty-four hours, and it is easy to see if the ratio between the meter load running through the day time and the peak load at night keeps on increasing, we must supply it away above our meter demands. Of course, all plants have to be over-installed, beside having spare units. They must have ability to reach exceptional peaks in the lighting business, such as demands made at Christmas and so on, but the ratio should not be too great; if it is, then you have too great a cost per unit of installation for your average load. When you have got that you have overburdened your plant with charges.

MR. HEGER: Are we not in the same condition as water companies supplying water through the eastern cities? Nearly all of them have kept their plants about the same and have increased their efficiency by introducing meters. I think that is true of nearly every water company in the larger cities, and electric lighting, while "in its infancy," is a pretty sturdy infant. Still, we are younger than the water companies, and could follow their example to advantage.

MR. MARTIN: The statement is quite true, but it is not a "deadly parallel." Our "coal bills" of water-driven plants are constant. Impress that on your mind and the other is easy to understand. In the case of the water supply companies this is not so.

MR. GILBERT: I think the gist of the whole subject lies in the difference in the way the power is furnished. Where power is in excess of demand the flat rate is the best. With a limited power I think there is no question that the meter is the only salvation for the plant, and I think the whole discussion really turns on the different classes of plant which are involved. I think the flat rate originated in a desire to get business in a way meter rates would not secure. In the early days of electric lighting when the coal bill was a large factor, we very soon found that the flat rate was a ruinous method of doing business; the difficulty was solved by selling current on the meter basis only. In summing up, I think with unlimited water power already installed and paid for, the flat rate would secure the earliest business, but I think the meter rate would have to be ultimately adopted to secure the best results.

DR. VAN NORDEN: I think we have all come to the conclusion in Sacramento that, for the present, the flat rate is best for us, while ultimately, when we get to the limit of our power, the meter rate will be quite necessary; but at the present time I think it is wise for us to adopt the flat rate as I think flat rates are getting us as large an amount of money for the horsepower as we could get if we sold it by the kilowatt-hour. Still, the time may come when we will lack power, and then we will undoubtedly adopt the meter system.

MR. MASSON: The fact a man requires an overcoat in winter does not show he needs one in summer. The Doctor wants a meter some day, but that does not show he wants one now.

THE CHAIRMAN: As the hour has arrived for the full members to go into executive session, the meeting will now stand adjourned until 8:30 p. m.

EVENING SESSION.

The convention reconvened at the appointed hour after dinner, President Pierce occupying the chair.

THE PRESIDENT: Our programme provides that at this time there will be informal discussions. Has any member any subject that he would like to bring before the meeting and have it discussed?

DR. PERRINE: I would like to ask expressions of opinion on the part of some of these practical men on the value of pins, cross-arms, and poles as regards insulation. Dr. Van Norden, in the paper by his son, read this afternoon, told of the value of treating pins with paraffine, and Mr. Martin and myself have had some discussion as to whether we could continue that insulation along the arms. Then the question came up, if you did that to the arms and neglected the poles, how far should the poles be treated. I have considered the matter very carefully, and have boiled our pins for about eight hours in an asphalum-tar mixture, and in lieu of something better that could be done immediately, I have creosoted our arms. Then the arms were put on a single bolt and braced with an iron brace. On later consideration it seemed to me that it was a mistake to insulate the cross-arms and then short circuit them with iron braces; so I talked the matter over with a mill man in Stockton and he suggested a wood brace, and sent me down a sample of arm braced with a wood brace, the arm having a mortise cut for holding the brace. One by two-inch braces were to be cut by a machine to an exact mitre and the whole construction seems very simple. I have presented this to a number of men and all the electrical men have said that a 2 x 1-inch wood brace would split. I have also presented this objection to all the mill men that I have been able to meet and they say that that is nonsense. They say a wood brace of that kind will stand perfectly well, as we have an example in fence pickets of about the same size, which last and which do not split. Then comes in the question of how far it is advisable to brace at all. The experiments that were made by the long-distance Bell Telephone Company show there is a decided advantage in boring one pole through cross-arms. Mr. Martin has bored one pole through cross-arms and has cut an inch deep in the pole, thereby making his cross-arm stand up all right without a brace, but weakening his pole. I have in mind a man who uses blocks on the pole alongside the arm, taking the place of the gain and brace altogether; but it does seem to me in long arms, say from five to seven feet long, if you use a single bolt and do not weaken the pole too much, not cutting more than half of three-quarters of an inch gain in a round pole, that the arms will require some bracing; and if you do brace the arm, and if you are going to have anything in the way of insulation in the arm, you must have a wood brace which is treated. The mill men here say that a treated redwood brace will stand all the strain necessary, will not split, and will accomplish the objct to be desired.

Now, there are a number of questions that come in there:

First. How is the best way to treat the pins, if you treat them at all?

Second. How is the best way to treat the arms, if you treat them at all?

Third. How is the best way to bolt the arms, whether with one or two bolts, and if we bolt them with one bolt, what is the limit in length of arm that is safe not to brace if you do not cut more than three-quarters of an inch gain in the pole?

My own idea is if we do treat the arms and pins, they should be treated with something along the procedure used in creosoting. There have been experiments in creosoting since long before the beginning of this century, in this and other countries, and all those experiments have apparently proved conclusively that creosoting is preservative and not a detriment only when the process thoroughly dries out the material. Then if you take ordinary timber — not green timber, but ordinarily dry timber — and creosote it or treat it in a couple of hours, that the timber will decay more readily than though it were not treated. Ordinarily, in arms we do not have to consider this decay. At the same time, if we do give any treatment at all, we have got to consider the question of decay, because if you do treat cross-arms and do not properly treat them, you will induce dry rot. So my impression is that we should treat pins and arms either by kiln drying or by cooking out in the treating process so thoroughly that we get rid of all moisture, and then penetrate as far as possible.

I started out with the original assumption that I would inject the arms and pins full of an insulating material, but after a long series of experiments, working with asphaltum and waxes up to 160 pounds pressure, I found it was practically impossible to inject a hardwood pin more than about one-sixteenth of an inch below the surface, and, in consequence, I have come to the conclusion that the best we can do is to thoroughly dry out pins and arms and give them a satisfactory coating. That coating I believe we can accomplish by kiln drying the lumber and then leaving it for from one to three hours in a mixture of asphaltum and drying oil. The ordinary pin insulating paint contains about 75 per cent. of bisulphide of carbon and 25 per cent. of asphaltum, and if arms which have been kiln dried are soaked in paint they become coated very thoroughly apparently with asphaltum, but as that asphaltum when it goes on contains 75 per cent. of bisulphide of carbon, it seems to me when it evaporates there is not much of insulation left. Accordingly I have come to the conclusion that our treatment can be better done with either pure asphaltum or an asphaltum coat with drying oil, or an asphaltum coat with turpentine, that will dry to a non-acid gum. I find you can get an asphaltum varnish made with turpentine at about 25 cents a gallon, whereas asphaltum made of linseed oils costs from 45 to 60 cents a gallon. The asphaltum varnish made with turpentine seems from the standpoint of the knowledge of the oil better than that made with linseed, because the linseed dries to an acid resin, and the turpentine dries to a non-acid resin.

Those are some of the points that have been troubling me directly, and I would like to hear if any of the men who have had experience in treating arms and pins and braces, and so forth, have anything to say, and also what are the ideas of persons who have not had any experience.

DR. VAN NORDEN: I would like to ask the professor whether he has had any practical experience on these lines, whether his theories have ever been put into practice in regard to the braces and the arms and the asphaltum and the pins. Are these theoretical considerations you have given us, or are they the result of experience?

DR. PERRINE: Not altogether. As regards insulating paints and the asphaltum coating I have had a good deal of experience with in insulating wires; and the common process of insulating wire is to pass a wire through a pot of hot asphaltum, braid on a cotton braiding, and then run it through an asphaltum pot again and polish it. That makes a very poor wire for the purchasing agents, because there are a lot of white threads in it. And, in looking around for something that would appeal to the engineer and purchasing agent both, I found that P. & B. paint gave an almost perfect saturation with a much cheaper process. All you have to do is to braid on a couple of braids of cotton on your wire without any soaking at all, and then run it through the P. & B. paint without any polishing, and it maks a perfectly soaked wire without a white thread in it.

DR. VAN NORDEN: I did not ask with reference to wires.

DR. PERRINE: The whole question of insulation must be treated together. The wire of which I speak sold well to the purchasing agents, but about the time that P. & B. paint came on the market, Leonard & Lizard of Chicago started testing the various water-proof wires. In every case a wire that had been insulated with an asphaltum coating that was made by a saturation solvent broke down before the insulations that were made simply with hot asphaltums and waxes. That is one practical consideration I have in regard to the treatment with something similar to asphaltum paint. What I ask for is some practical experience similar to that, and in regard to cross-arms.

DR. VAN NORDEN: It is that I want to give over against these theoretical considerations, which may be of great value for all I know. I can place our experience on a line of about thirty-five miles in all, and 16,000 volts. We fully believe, as the result of our experience, in the iron braces. We have been running for several years, and during all that time we never had our attention called to those braces as a source of weakness; never in any instance. We had an insulator on the top of our pole which was attached to the pole by means of an iron bolt, through to a V-shaped iron arrangement attached to the top of the pole by lag screws, and the current leaking through the insulator would work down the bolt into the V-shaped iron and thence through the lag screws into the heart of the wood, and we had difficulty with the upper pin so long as that wood had sap in it. As soon as the sap was entirely dried out it gave us no trouble. I believe it is a great deal better to have a shallow gain and to attach a couple of iron braces to the arm by means of lag screws.

With regard to the arms, we never had any burning of arms, or any trouble that resulted by reason of the fact the arms are not insulated. I don't think it is necessary to insulate the arms at all. So far af the pins are concerned I don't think a pin could possibly have been put to a better test than ours at this end of our line where the energy was 12,000 or 13,000, near Sacramento, where, as was stated in the paper written by my son, for a mile and a half we had ordinary glass telegraph insulators. These were very simple affairs indeed, and we watched them in every kind of weather. So far as any report has come to me, or any observation we have made, and we have looked into the thing pretty closely, no pin has ever been burned, no arm has been burned, and there has been no indication whatever of leakage. Judging from our experience with the larger insulators on pins that were not boiled in paraffine, we believe, if our pins had not been boiled in paraffine, that the experiment would have been a total failure. We do not believe the paraffine acts as an insulating material, and do not think on that account that the comparison with asphalt is of very much value. A good, dry pin is a good insulator itself, and the paraffine makes it impervious to water, absolutely so, so that the pin never gets damp and never becomes anything but an insulator, and never becomes a conductor. Our success with small insulators is owing to that fact, and we are quite confident we might replace all the large glass insulators and put on little ones all the way to Auburn without any damage whatever to our system, provided we first boiled the pins in paraffine.

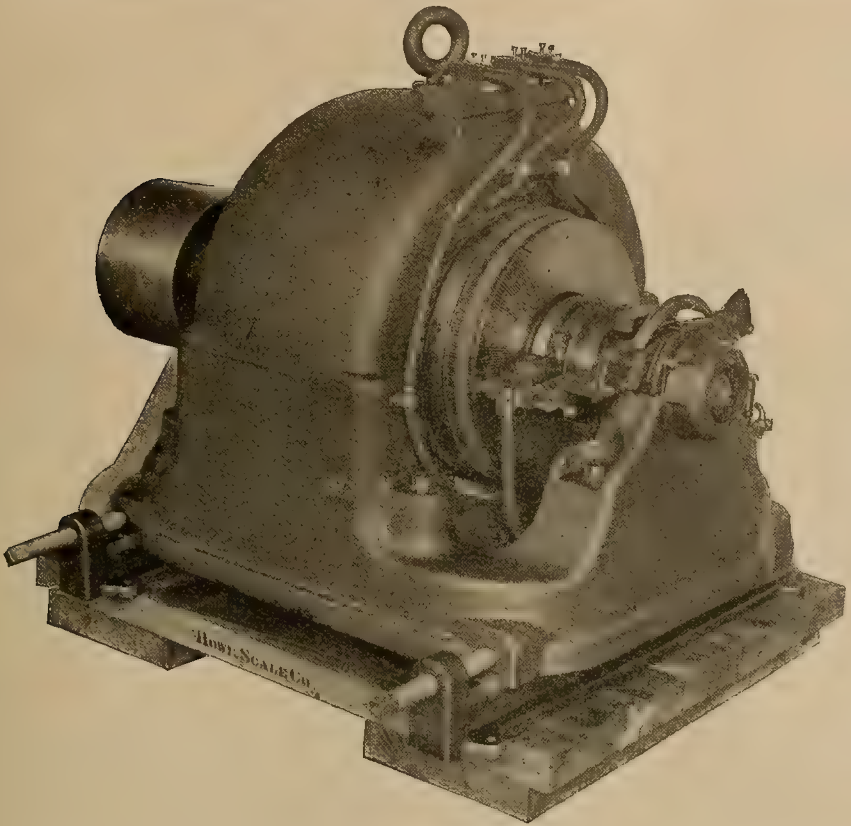
I regret I must disagree with the professor on all these three points, and I think back of my opinion is a very good and long experience. I think the arm should be supported by braces; I think the gain should be shallow; that the arm need not at all be insulated, and that you need do anything but cover it with some paint, say P. & B. paint — something of that sort — mainly to keep the wood from becoming soaked. That which does the work is the paraffined pin; I attach immense importance to that, and I believe we could reduce the expense of our insulators very largely indeed if we would use paraffined pins.

(Continuation in next number.)

Distribution

SINGLE-PHASE SELF-STARTING MOTORS.

SEVERAL different types of alternating-current motors have been described in these columns heretofore, and it is in order to similarly illustrate at the present time the latest form of single-phase self-starting motor—that of the Wagner Electric Manufacturing Company—that has made its appearance. This is well described in a paper read by W. A. Layman before the students of the Rose Polytechnic Institute, from which the following is taken. In the preparation of the paper it was assumed that the greatest value would be derived by avoiding a discussion of the finer theoretical questions involved, thus confining the paper to practical aspects.


THE WAGNER MOTOR.

The incentive to produce a commercial single-phase motor has been very great since the earliest comprehension of the general properties of the alternating current, for the reason that practically this one element alone has been lacking to make the single phase system of current distribution the highest form of development in the field of central station practice. Many able investigators have devoted time and thought to it, but until a comparatively recent date scant reward in the way of a practical and durable form of motor has repaid their efforts.

Early efforts to produce such a motor were broadly confined to two characteristic types:

First. The synchronous motor.

Second. The direct-current motor especially constructed to operate on alternating currents.

In the synchronous motor the fields are magnetized by a direct current, and the armature is supplied with alternating current corresponding in wave form and frequency to the current which the same machine would produce, at the same speed, operating as a dynamo. Two disadvantages arise, namely, *such a motor will not start from rest*, and, furthermore, to avoid fluctuations of the current necessary to operate with or without load, *the strength of the field must bear a definite relation to the load*. Such relationship is maintained with difficulty, and sometimes when the load is very irregular it cannot be maintained at all. When this arises the motor causes pressure fluctuations over the entire circuit from which it is supplied, practically crippling incandescent lighting from the same mains.

Many ingenious efforts have been made to overcome both difficulties, and not without a fair degree of success in one or two forms of motors. Two well known manufacturing companies have deemed their success such as to warrant them in putting single-phase synchronous motors upon the market. These companies were the Fort Wayne Electric Corporation and the Excelsior Electric Company. In the Fort Wayne motor no attempt was made to overcome the line pressure fluctuations with variable loads, and the designer's ingenuity was entirely confined to developing a satisfactory starting device, and providing for the self-excitation of the motor after up to running speed.*

The motor built by the Excelsior Company, in so far as Mr. Layman's information goes, differs from the Fort Wayne motor in that it has one or two refinements lacking in the latter. The Excelsior Company has endeavored to accomplish an automatic regulation of the field strength to the needs of the motor by introducing a small series transformer in the armature supply circuit. The secondary current from this series transformer is rectified by means of a two-part commutator, and sent into a special field winding. The second field winding corresponds to and serves the function of the compound winding in a direct-current machine, and, it is claimed, accomplishes the object of steadying the armature current with some degree of practical success. The criticism on this motor is that it is complicated, having two commutators and a pair of collector rings, two field windings and two armature windings.

Just what degree of success these companies have met with in introducing motors for practical power purposes has not been authoritatively stated, but the synchronous motor has certainly found one field in which it serves at present an almost indispensable end. This is in its application as a rotary transformer to the derivation of direct currents from alternating. For this service it has generally been designed to operate on two and three phase circuits.

The second general type of single-phase motor attempted by early investigators, namely, the direct-current motor constructed for alternating currents, has also run the gauntlet of innumerable efforts to make it practical, but has entirely disappeared for all

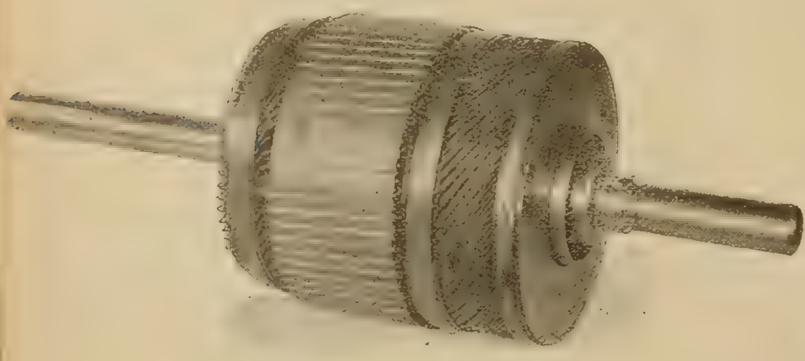
THE FIELD AFTER WINDING.

---

*See the illustrated description in the JOURNAL, Vol. V, page 131, Sept. 1897.

kinds of work except those involving very small amount of power. Aside from other disadvantages, this motor is barred from the field by the one consideration that electrical actions arise in the armature which make the destruction of the commutator by sparking very rapid. This feature of armature trouble is worthy of some discussion in detail. It arises from what may be termed a transformer action taking place in the machine.

All are familiar with the fundamental fact in alternating-current work, that a conductor introduced into an alternating magnetic field will have induced in it alternating currents, conforming in periodicity with the periodicity of this field, application of which is made in the familiar static transformer wherein a primary coil is wound upon an iron core and a secondary coil also wound upon the core, has alternating currents generated in it by induction when an alternating current is supplied to the primary coil. Exactly the same thing takes place in the armature of the direct-current motor when it is attempted to operate it upon alternating currents. The effect of this action may be seen in Figure 1.


A SINGLE-PHASE MOTOR ARMATURE.

The coil *C*, which is a portion of the armature winding, is in the position, when by its rotation alone it is generating no electrical pressure, and therefore supplying no counter electromotive force. In the direct-current motor this wire is practically dead at this instant. With an alternating magnetism, however, the coil is in the position to act as the secondary of a transformer, and since it is short-circuited by the brush bearing upon the commutator, it is evident that a heavy current will flow through it. When this short circuit is broken by the brush passing on to the succeeding segments of the commutator, heavy sparking results. This sparking is such as to make continuous operation in this manner altogether impracticable.

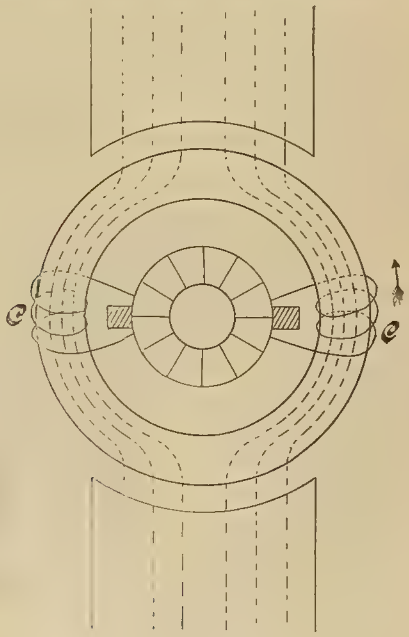


FIGURE 1.

The single-phase alternating-current motor, therefore, in so far as these two types of construction go, has proven to be largely a practical failure, and it has only been in recent years, since the discovery of the principle of operation of the induction motor, that there has been offered to investigators any promise of success in this field of development. Since the introduction of the induction motor, several avenues of promised success in single-phase work have been opened up. In all, however, the fundamental element of success is the proper application of the induction motor principle.

The induction motor is nothing more nor less, from one point of view, than a special form of the alternating-current transformer. It consists of three elements:

1. A primary circuit or field.
2. An iron magnetic circuit.
3. A secondary circuit or armature.

In other words, it is a form of motor construction in which the outside supply circuit feeds the field windings only. By its function as a transformer, the motor generates for itself armature currents, which currents, under proper control, set up rotation.

Its earliest exemplification was in a type of construction probably designed to run upon the same general principle as direct-current motors. This was the motor devised by Messrs. Anthony, Jackson and Ryan, illustrated in Figure 2. Here the armature still is of the same construction in all details as the ordinary direct-current motor, wherein the brushes bearing on the commutator are connected to a locally closed circuit in which is introduced resistance, the amount of which may be varied at will. In operation, an alternating current sent into the field produces by induction alternating currents in the armature, and these armature currents are commutated to produce rotation. Notwithstanding this great advance, commutator sparking still existed, and although this motor was brought out as early as 1887 nothing has ever been done with it commercially, except in a special use, as will be hereafter described.

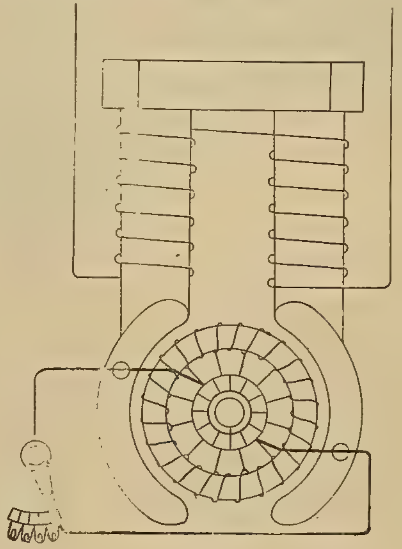


FIGURE 2.

The Anthony, Jackson and Ryan motor, although operating purely upon the induction principle, was not what is generally known today as the induction motor. Tesla found that commercial results could be secured if currents of two or three phases were used to produce a so-called rotating magnetic field; or, in other words, the effect of a strong magnetic pole revolving around the surface of a short-circuited armature. In a form of motor such as Figure 3, he would wind what would ordinarily be a twelve-pole machine in such a manner as to give him three sets of four poles. Into each set he would introduce one phase of a three-phase current supply. The poles produced by one phase, or for example, *A A A A* would be immediately succeeded in point of time by poles produced in *B B B B* by the next phase of current, and so on around the periphery of the field, thus shifting the pole from *A* to *B*, *B* to *C*, etc. With such a field winding, it was found well to use a form of armature such as is illustrated in Figure 4. In this armature the winding of copper conductors consists simply of a large number of bars completely short-circuited at both ends, with respect to each other, by a copper ring. The resemblance of this form of winding to an old-style squirrel wheel gave rise to the popular name of a squirrel-cage winding. Such an armature, placed in a rotating magnetic field, will start from rest with a great deal of torque, and will quickly run up to a speed slightly less than the number of alternations of the current supply, divided by the number of poles of the winding. However, such a motor supplied with single-phase currents will not start from rest, and therefore, up to this point, the induction motor is not practicable for single-phase circuits. This arises from the consideration that a single-phase current will not produce a rotary field *while the armature is at rest.* The currents generated by induction in the armature conductors when the armature is standing still, select such paths of flow as to produce no resultant turning couple, with reference to a stationary field pole. Some of the currents tend to produce rotation in one direction, others in the opposite direction. They nullify each other in so far as the turning moment goes. In the two and three phase motors a different condition exists. The currents produced in the armature by any one set of poles bear the right relation to the poles of the next phase to afford an effective turning couple, and therefore the multi-phase motors are very effective in starting from rest.

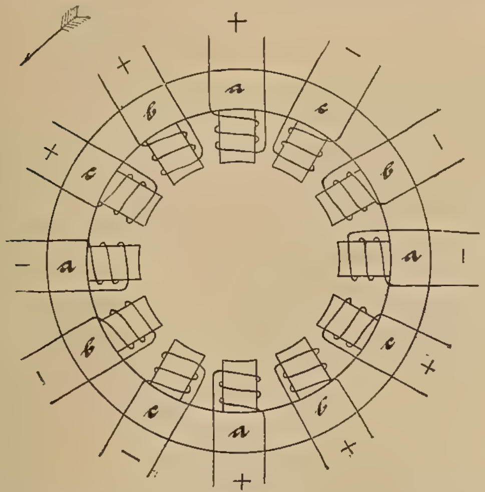


FIGURE 3.

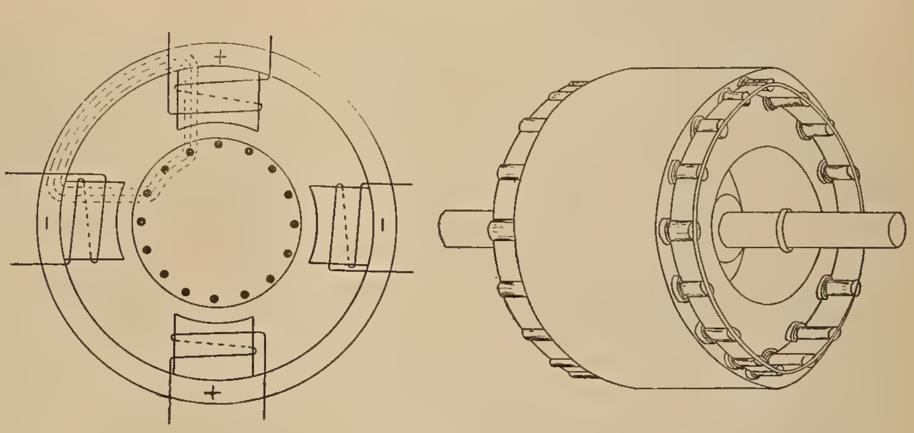


FIGURE 4.

When up to running speed, however, a motor constructed for a single-phase supply, *with armature corresponding to that of multi-phase motors*, will run in all respects practically as well as a two or three phase motor. In other words, the disadvantage of the induction motor operating on a single phase, as compared with two or more phases, is that the motor will not start from rest, but requires some auxiliary device for starting.

In the development of starting devices, several types of motors have been produced, and these may be spoken of in general as *modern single-phase motors*, thus distinguishing them from the motors previously described. These motors have taken two forms:

First. Those in which two and three phase currents are produced *artificially* from single-phase current, for the purpose of creating a rotating magnetic field in starting.

Second. Those falling back on the principles of the direct-current motor for starting.

In the first class might be placed all of the two and three phase motors of today, where the construction is such that the entire field winding can be fed either from single phase or polyphase without changing the number of poles. In other words, a standard two-phase or three-phase motor could, if properly connected, be fed from a single-phase circuit and operated on single-phase currents, *after having attained running speed.* But for starting, various devices are resorted to for phase splitting, as it is termed, to artificially produce two and three phase starting currents. Some of these devices are fairly satisfactory. The fault with all is that a very large amount of energy is taken from the supply circuit to produce differences of phase which are *variable* from low speeds up to full speed, and which, furthermore, do not provide a large amount of torque.

The second type of motor has been brought out by the Wagner Electric Manufacturing Company of St. Louis. Broadly speaking, it may be said that this motor starts according to the method first used by Messrs. Anthony, Jackson and Ryan, and illustrated in Figure 2. After getting up to running speed, connections are automatically changed so as to transform the motor into an induction motor pure and simple. This is accomplished by a complete short-circuiting of the commutator at running speed.

In mechanical construction, this motor is, in many respects, very similar to that of the two and three phase motors upon the market. A field is built up of iron plates very much like *A* of Figure 5, and an armature core is also built up from iron plates very much like *B*. The field is wound with so-called pancake coils threading through the slots of the punchings, as shown at *C*, thus producing a magnetic pole of intensity, varying from a maximum along the radius *X Y* to zero along the radius *X Z.* The armature core is wound with an ordinary direct-current progressive winding, connected up to a commutator in exactly the same fashion as is the direct-current motor winding. The commutator of this armature is so designed that it may be completely short-circuited by introducing into it a short-circuiting circle of copper segments. When so short-circuited, the winding affords a substitute for the squirrel-cage form of winding, but differing therefrom in that instead of currents being able to select paths for themselves, they are restricted to flowing in paths afforded by the individual coils.

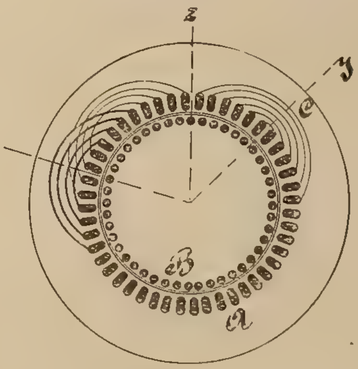


FIGURE 5.

The operation of this motor is based wholly upon the principle that an induction motor with a completely short-circuited armature will, when up to the running speed, operate on single-phase current supply in exactly the same manner as does a two or three phase motor with two or three phase current supply. Therefore, after the advent of the rotary field induction motor, the problem to be met in developing a successful single-phase motor was the provision of a starting device which would afford ample starting torque at all speeds between rest and running speed, without excessive consumption of current, and of a mechanical construction equally durable with the rest of the motor. In doing this there has been brought out a line of small motors claimed to be equal to the best two and three phase motors.

As to its starting characteristics of torque and current, the Wagner motor is said to correspond closely with the series direct-current motor. The armature winding is, however, short-circuited through carbon brushes bearing upon the commutator surface, and the currents flowing in it are generated by induction from the field. These currents flow out through the carbon brushes either into an outside resistance box, or where a direct short circuit of the brushes is provided, out through one brush and back into the armature through the other. By the shifting of the brushes on the commutator surface, they are forced to take such position relative to the magnetic poles of the field, that repellant action between them and the poles of the fields is effected, and rotation results. In other words, the currents which would be ineffective in the induction armature at rest, are forced to take such positions that they become equally effective with the starting currents produced in the armatures of two and three phase motors. When running speed is attained, the brushes are no longer required and the armature winding is completely short-circuited, as stated. In the mechanical development of this form of motor, many novel features have been introduced. The commutator is of a radial, instead of the horizontal type. The short-circuiting ring is made up of small copper links, which links, being in turn mounted upon a short-circuiting band, are thrown into the annular opening in the commutator, and by making close contact with the individual segments produce a very effective short-circuiting of the entire armature winding. (Figure 6.) In the operation of the motor, it is very advantageous to have this short-circuiting operation performed either at or slighty below the running speed. To remove all uncertainty of this being done at the proper instant, these motors are built with an automatic device for performing this operation. This device consists of a set of governor weights acting against a spiral spring. The centrifugal action of the weight will, at the proper speed, force the short-circuiting links into the commutator, against the action of the spring. At the same instant and by the same means, the brushes bearing upon the commutator are thrown off.

The makers claim that these motors are so designed as to carry a large percentage of overload without any serious consequence, and that if this capacity for overload is exceeded, the motor will come to rest in exactly the same way as will a two or three phase motor under the same conditions. If the overload is temporary, however, the motor will, without attention, run back to speed, as in slowing down the brushes are automatically thrown back on the surface of the commutator, and the motor is again placed in a starting condition.

With this motor, as with any electric motor, the points to be considered in determining the excellence of design are:

1. Its starting torque.
2. Its starting current.
3. Its consumption of energy while running idle.
4. Its efficiency at all loads.
5. Its power factor.
6. Its drop in speed with load.

The starting torque of this form of motor can be made, by adjustment, large or small as desired; a feature certainly very desirable, since the consumption of current in starting is proportional, practically, to the torque. This adjustment of torque is accomplished by shifting the brushes upon the commutator surface. When the motors leave the factory, the brushes are set so as to just bring up full load. The relation of torque and current under this condition is shown in Figure 7.

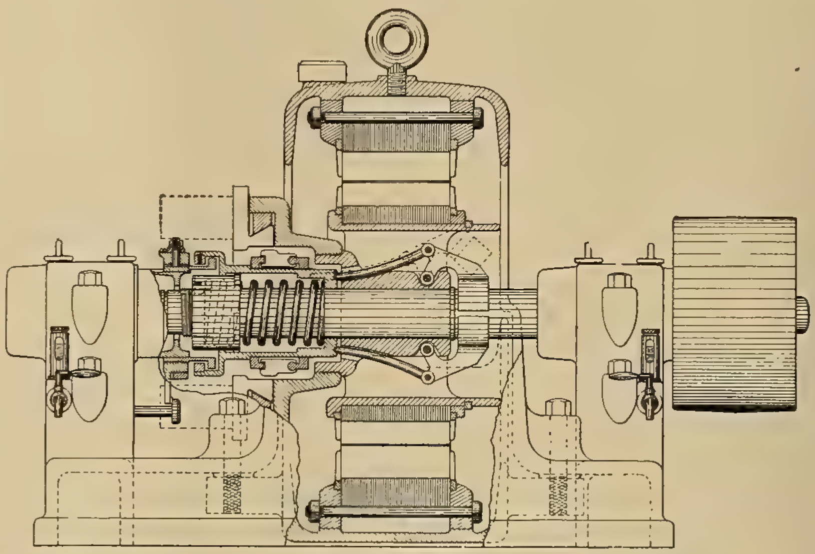


FIGURE 6.—CROSS SECTION OF WAGNER COMPANY'S MOTOR.

The energy required to operate the motor without load is very small, being practically the same as that required by direct-current motors. The efficiencies which have been secured in these motors are also practically identical with those secured in the best direct-current motors. The power factors are as high as those secured in two and three phase motors, and the drop in speed with load is very small indeed. In Figures 9 to 15 are shown the results of a test upon a five-horsepower sixty-cycle motor, made by students of the University of Nebraska, during the spring of 1898, under the direction of Prof. R. B. Owens. One set of tests there made

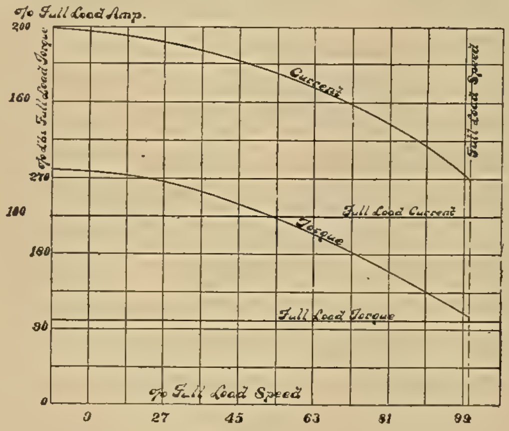


FIGURE 7.

was the measurement of the various electrical factors with different applied electrical pressures at the terminals of the motor. In other words, the motor as sent out by the builders was designed to operate on a pressure of 104 volts. Tests were made with a variation of this voltage in steps between 70 and 120. The effect of these various voltages upon the various factors are very nicely illustrated in Figures 9 to 11 inclusive. The judiciousness of the ratings given by the builders is very clearly brought out in these

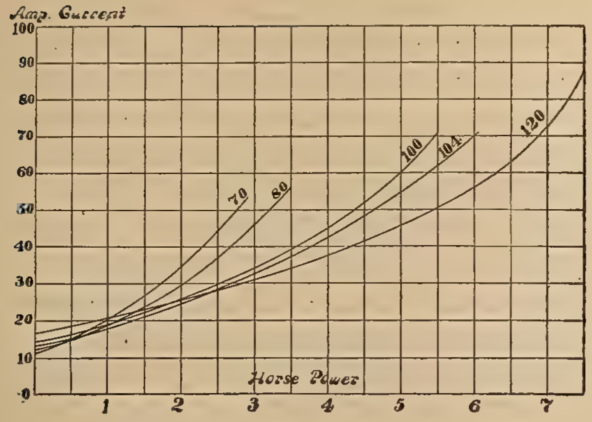


FIGURE 9.

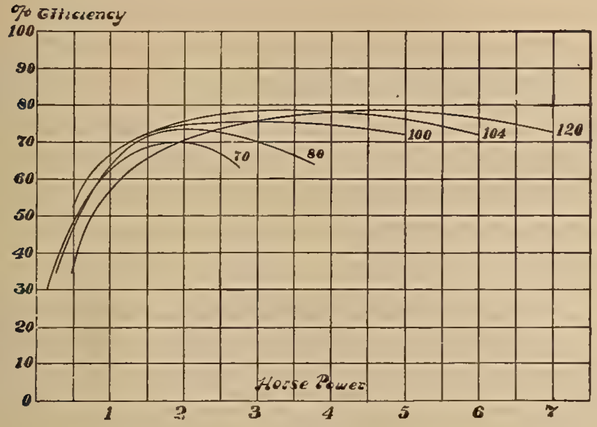


FIGURE 10.

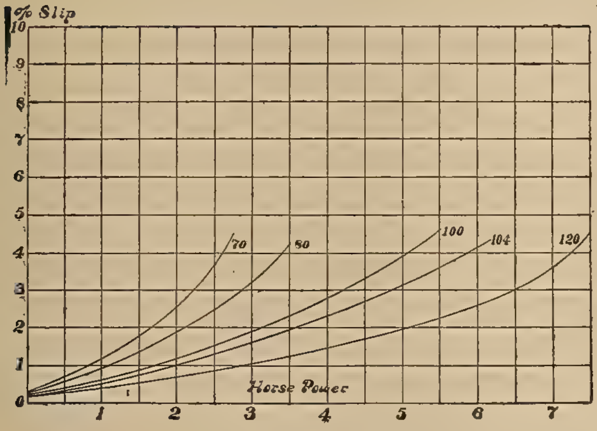


FIGURE 11.

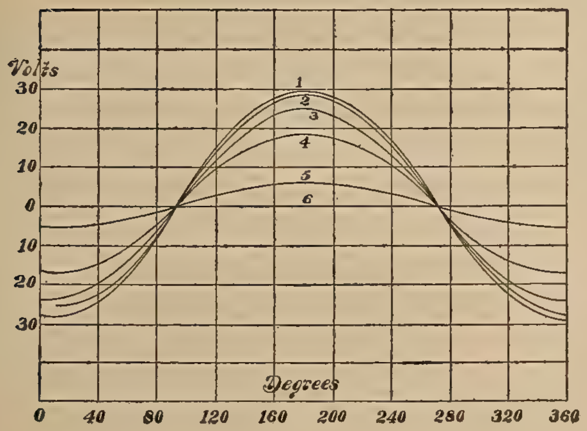


FIGURE 12.

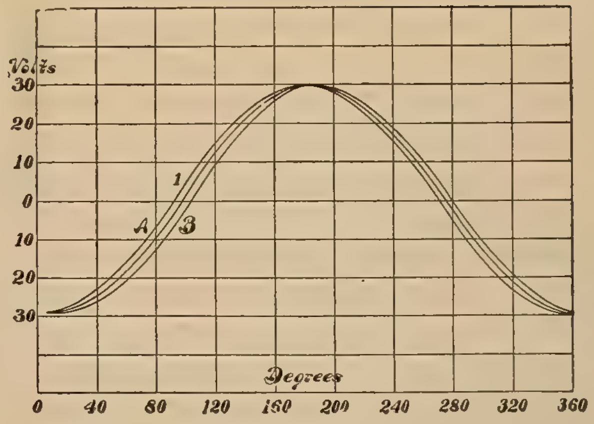


FIGURE 13.

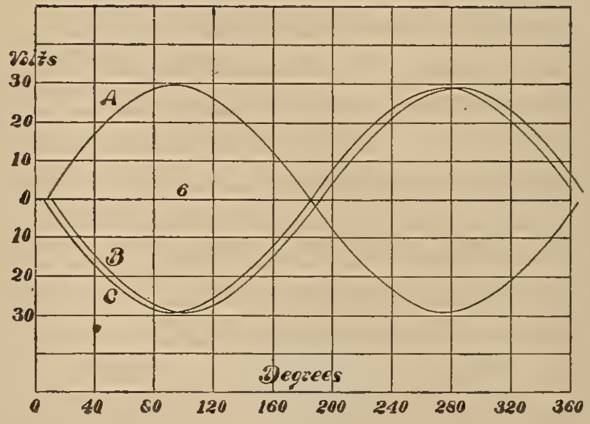


FIGURE 14.

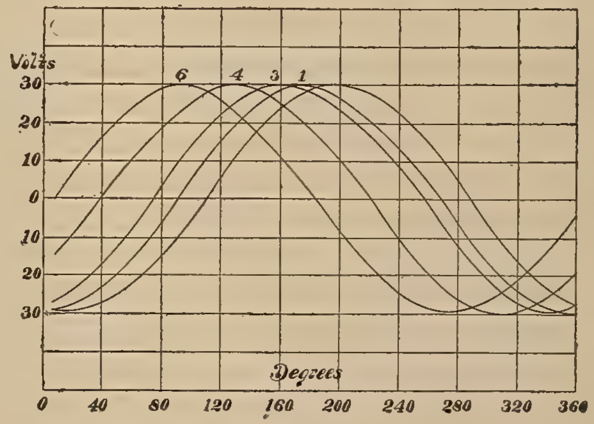


FIGURE 15.

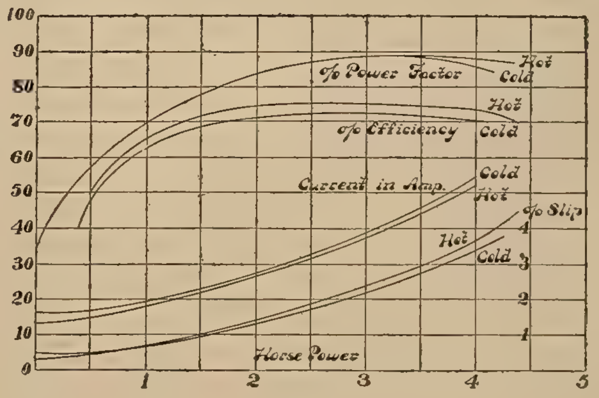


FIGURE 16.

curves. A particularly noticeable feature is the small percentage of slip at the rated capacity of the motor, namely, three per cent.

Another set of tests made at the University of Nebraska, was a determination of the exact magnetic actions going on in the motor. In other words, the students attempted to determine, under all conditions of load as well as when standing idle, the exact form of magnetic field produced by their single-phase sine wave current supply. For this purpose they introduced exploring coils in the slots of the field punchings. Each of these exploring coils embraced one-fourth of the slots of the entire field corresponding in that way to the exact breadth of the polar winding of the motor. These exploring coils were introduced progressively around the frame in such a way that the first one enclosed the entire winding of one pole, the next one $\frac{8}{9}$ of the winding of the first pole, and $\frac{1}{9}$ of the winding of the next pole; the third one enclosed $\frac{7}{9}$ of the winding of one pole, and $\frac{2}{9}$ of the winding of the next, etc., progressively until a point was reached where half of one pole and half of the next pole was enclosed. By the proper introduction of measuring apparatus they could tell just what the magnetic strength in the section of the field embraced by each coil was at any instant. Therefore, plotting these instantaneous results with respect to time, they could determine the exact form of wave and its net numerical value all around the interior surface of the field punchings. In Figure 12, the results of their tests are shown with the motor standing still. The result here is just what might have been expected, namely, that in this condition of affairs, the field is a pulsating one and decreases in magnitude at any instant as you progress around the circumferance from the central radius of each pole. In Figure 13 is shown the reactive effect of the armature upon the strength of the field immediately in the center of each pole winding, between the limits of no load, half load, and full load. The displacement seems to correspond in per cent. to the per cent. of slip. In Figure 14 are plotted the reactive effects on the magnetic field caused by the rotation and the current of the armature winding. A close study of these curves as compared with the curves of Figure 12, reveals the fact that the armature reactions of the motor when up to speed are such as to entirely change the character of the magnetic field, actually producing as perfect a rotating magnetic field as is created by a multiphase current supply. In Figure 15 is shown the reactive effect of the armature upon that portion of the field embraced in the exploring coil which gives a horizontal line in Figure 12. Here curve 6 shows that the resultant magnetism enclosed by this exploring coil is zero when the motor is at rest.

Curve *A* shows the condition of affairs with the motor running in one direction. Curve *B* gives the corresponding result with the motor running in the other direction. Curve *C* shows the displacement of *B*, due to load on the motor. These various magnetic curves are worthy of much closer study than can be given in the limits of this paper.

Another test made by the University students was to determine the effect of continuous load upon the motor. In other words, to compare the electrical conditions of the motor operating cold and hot. These results are shown in Figure 16, and disclose the fact that the motor is more efficient and operates with better results in every respect except slight increase in the percentage of slip, when hot than when cold.

In the winding of these motors, it is possible for the builders to secure a variety of results; for instance, where a large starting torque is required, an auxiliary connection can be made, the effect of which is to rate up the motor in capacity. The builders term this a loop connection, and for this connection provide a third terminal upon the terminal board. If the circuit is connected to this terminal and the common terminal for starting, 50 per cent., 75 per cent., and in extreme cases 100 per cent. overload may be brought up to running speed. When up to running speed connections are changed by means of a throw-over switch in the supply circuit, so that the current is supplied to the normal winding of the field.

The extreme simplicity of the motor arises from the fact that it can be connected upon the same circuit with incandescent lamps and operates thereon without any disadvantageous effects. Furthermore, operating on a low tension, there is no danger from accidental contact. If it is desired to operate on higher voltages, windings will be provided to correspond. The manufacturers have designed alternating-current motors of this character up to and including 20 horsepower capacity for 60 cycles, and 15 horsepower for 133 cycles. Larger sizes are to be brought out in the near future. The limit of adaptability of this motor to various kinds of power work is set by the frequency of starting necessary, as explained above. The motor can not be continuously operated upon the commutator, and in so long as the starting is of infrequent character, satisfactory results can be guaranteed. For ordinary running service, where starting but once or twice a day is necessary, the life of the commutator is indefinite.

Obituary

HERBERT H. BROOKS, late general manager of the American Circular Loom Company, died at his home in West Medford, Mass., on July 9th last. Mr. Brooks had been a sufferer from consumption for several years and had made trips to California, Mexico, the West Indies, and other points in the effort to restore his health, but all were without avail. He had been connected with the American Circular Loom Company since its inception, and had much to do with perfecting the well-known form of flexible conduit which his brother, now deceased, invented.

The death of Mr. Brooks recalls tender memories of the few days spent by the writer at the charming old homestead in West Medford, where for generations the Brooks family has lived. Interesting though the old home was, with its almost countless colonial treasures, this interest paled in the light of the beautifully tender affections thereever existing between mother and sons. Mrs. Sarah W. Brooks, now probably in the eighties, is all that intellectual refinement and ripened experience can make of noble womanhood — no ideal is higher — and one of her books, that on "English Poetry and Poets," is among the best reviews on English literature which has ever appeared. In her son, whose untimely death is now mourned, the electrical world recognized a man who courted and won success by unyielding fairness, who was so thoroughly good that he could not see evil in others, and who, above all else, attained an element of popularity that was closely akin to true affection. No one ever spoke ill of Herbert H. Brooks: no one could; but however high his memory may stand in the esteem of his fellow man, there is still a higher niche that it can occupy in the minds of those who knew his inner nature as revealed in the beautiful tenderness of his home life. Mr. Brooks never married, but leaves a mother and brother who, though they feel the depths of grief, are among thousands who mourn his loss.

AUG. I. NEISSER, well known to the electrical interests of the West, and more especially in California, died in Los Angeles during the latter part of July. Mr. Neisser had long been a sufferer from consumption and some three years ago moved his place of business from San Francisco to Los Angeles that he might escape the rigors of the summer winds of the metropolis. This move undoubtedly prolonged his life, but the end was inevitable, even in the salubrious climate of southern California. He was best known as the Pacific Coast representative of the Central Electric Company of Chicago, and all, even to his keenest competitors, have always conceded to Mr. Neisser the credit of a fairness, thoroughness and earnestness in business that is exemplary. Personally, Mr. Neisser was a charming character, his whole energies being devoted to furthering the comfort and well-being of his parents, brothers and sisters. Although no information is at hand, yet is probably safe to say that his business will be conducted by his brother, Otto Neisser, who has for some months been in charge of the late Mr. Neisser's San Francisco office.

THE JOURNAL OF
ELECTRICITY, POWER AND GAS.

VOLUME VIII. SAN FRANCISCO, SEPTEMBER, 1899. NUMBER 3.

A Typical Small Street-Railway Plant.

BY HARRY J. BEAN, A. B., E. E.

SANTA CLARA COUNTY contains within its borders two electric railway lines that are among the first of of those installed in California, namely, the San Jose and Santa Clara Electric Railroad Company's line, which began operations in 1889, and the First Street Electric Railroad Company's system, which was installed during the year following. These two plants are duplicates except in routes and minor details, hence a description of one suffices for both, but being more familiar with the details of operation of the First Street system, it will form the subject of this article.

The first portion of the system installed consisted of the line running on First street from the power house to Hotel Vendome, thus traversing the main business and residence street of San Jose. In 1891 the line was continued southerly on First street to Oak Hill Cemetery, and during the two years following the remainder of the system comprising nineteen miles of track, was built by the personal enterprise of Jacob Rich, who, up to and during 1893, expended $475,000 in construction and operation of the system. The lines extended away out into thinly-settled suburbs and did not pay; the financial depression of 1895-6 followed closely, and, although the system was brought to a paying basis a year or so ago, it was sold under foreclosure in May last to the German Savings and Loan Society of San Francisco for $225,000.

Having thus briefly reviewed its historical and financial sides we may turn to its mechanical and electrical features: The power house is of wood with corrugated iron roof. It is 96 feet long by 50 feet wide, and a wood partition separates the boiler and engine rooms. The boiler room and two-thirds of the engine room are laid in cement, the remaining one-third of the engine room being floored with asphaltum. The building is without ceiling or lining, is situated a trifle over a mile from the center of the city. The ground plan of the power house, together with the general arrangement of its contents, is shown in Figure 1. Two boilers of the "porcupine" type, each rated at 150 horse power, are used. They are hand-fired with pine wood in four-foot lengths. Other woods as well as coal have been used from time to time, but pine wood has been found to be cheapest fuel by a very small margin. A great deal of sediment and scale is deposited in the heater, and in time the tubes and sides of the boilers also become coated with scale, which is cleaned off monthly. When a boiler is to be cleaned, on a Friday night a half-bucketful of a patented boiler compound is injected into the boiler, and on the following night the boiler is shut down. On Sunday night the fireman takes a hose into the boiler and plays the hose into each tube and against the sides of the boiler, and as the compound has reduced the hard scale to a soft mud, the water washes the mud off leaving the boiler perfectly clean without scraping. After cleaning, and before the manhole is closed, another half-bucketful of the compound is thrown into the boiler, and the boiler is put into service again the next day. Many other compounds have been tried without success, and coal oil was found to be also useless, for after having applied it the scale hardened so that it was impossible to even scrape it off.

Two duplex steam pumps, either of which may serve as a feed pump or a tank pump, are used, as is also an injector. All

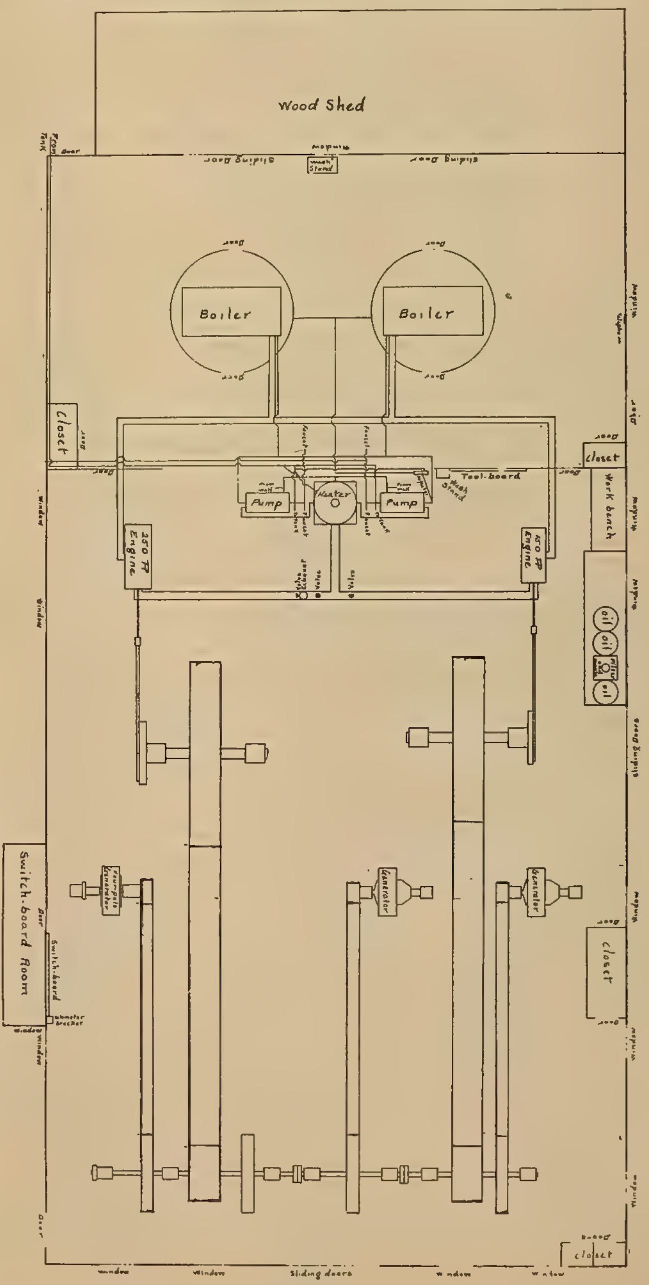


FIGURE 1.

feed water comes from the heater, but should it get out of order, cold water from the well may be put into the boiler from either pump or by the injector. The draft is hand-regulated, the chimney is provided with a damper, and steam is kept at 90 pounds per square inch. The feed water heater, shown in section in Figure 2, is circular in form, and made of boiler iron. It is 3½ feet in diameter by 10 feet in height, and a perforated partition about one-third of the way up divides it into two chambers. The upper chamber is about two-thirds full of rocks, and immediately under its exhaust outlet is a large sprinkler supplied with water from the tank. The lower compartment is kept half full of water, and its level is maintained by the automatic arrangement clearly shown in the figure. Exhaust steam is admitted into the upper half of the lower compartment, whence it rises through the perforated partition and between the rocks, and thence into the atmosphere. The action of the heater is very simple, for the exhaust steam heats the rocks and practically condenses while the water from the sprinkler is heated from contact with the steam and in cooling the rocks. Hot water for the boilers is taken from that in the bottom of the lower compartment of the heater. Every two months the heater is cleaned, as it then becomes necessary to take out the rocks and chip the deposit from them, as well as to clean off the scale and sediment from the heater itself. The heater is too small to handle the exhaust of both engines.

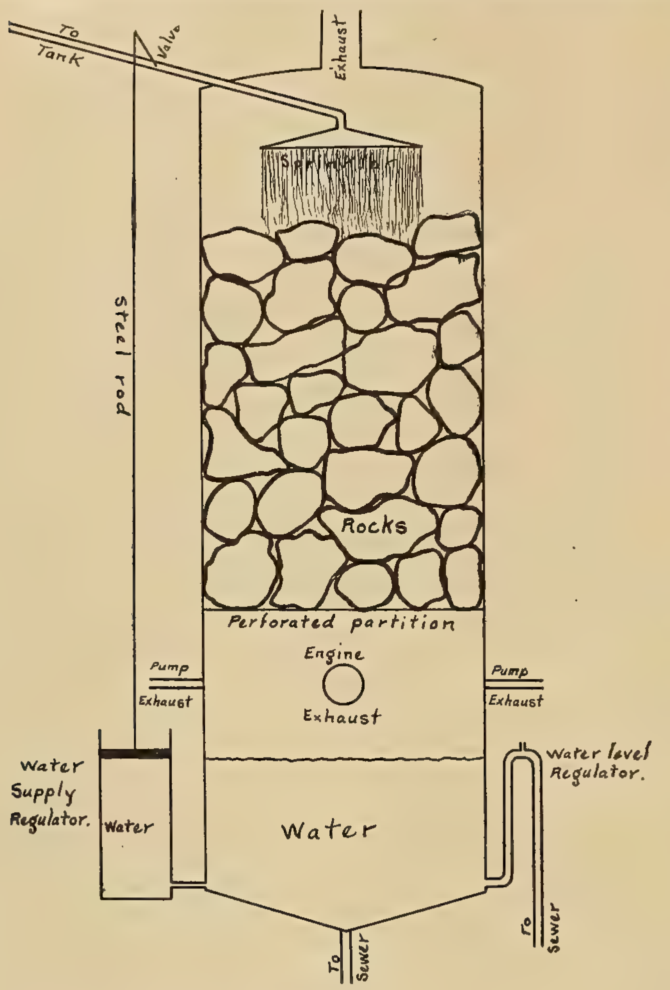


FIGURE 2.

The power plant consists of two "Wheelock" variable cut-off engines erected on concrete foundations. The smaller engine was the first installed, and it is rated at 150 horse power at 74 revolutions per minute, its cylinder measuring 18x42 inches. The larger engine was put in in 1893, and it is rated at 250 horse power at 65 revolutions per minute, its cylinder being 20x48 inches.

The generators originally installed were two of the well-known "D62" type of Thomson-Houston make, delivering 120 amperes at a nominal voltage of 500. The next machine was installed in 1893, and it is one of the equally well-known "MP100" railway generators of the General Electric Company. Both engines are belted to a jack shaft, from which the generators are driven, as appears in Figure 2. These generators are erected on concrete foundations and have leather-covered pulleys.

The switchboard is of the standard General Electric "form K" type in three lignum vitae panels. The essential features and circuit connections of which are shown in Figure 3. In Figure 4 is given the load curve for March 28, 1899, as taken by F. G. Baum and the writer. Readings of the voltage and current were taken every six minutes from the time of starting (6 a. m.) until midnight when the plant shut down.

All feeders are of No. 0000, and the trolley wires are of No. 0, B. & S. copper. The rails are light, weighing 30, 35 and 50 pounds per yard on different branches, and the first device for rail-bonding and return circuit consisted of a No. 3 bare copper wire laid midway between the two rails underground along the length of the track to the power house. The rails were connected by two fish plates, and one foot from each end of every rail a seven-sixteenths inch hole was drilled through the flange of or foot of the rail, and into this hole a No. 5 bare wire was inserted so that about an inch of the end of the wire would protrude beyond the flange. A channel pin was then driven into the hole, thus making the well known form of driven bond so generally used some years ago. The No. 5 wire was then given three turns around the No. 3 wire without soldering, and the other end of the No. 5 wire was then driven-bonded into the flange of the adjoining rail. This form of bonding was abandoned long ago. The second form of bonding was also of the driven-bond type, the difference from the first being that the bond was carried from rail to rail without depending upon the underground return wire, and a No. 0 wire was driven-bonded into the web of the rail. The trouble with this bond was that the channel pins dropped out, and now the method which has been adopted consists of using the same form of bond as that preceding, with the exception that the ends of the wire are left longer and are bent toward each other and twisted together, thus preventing the channel pins from falling

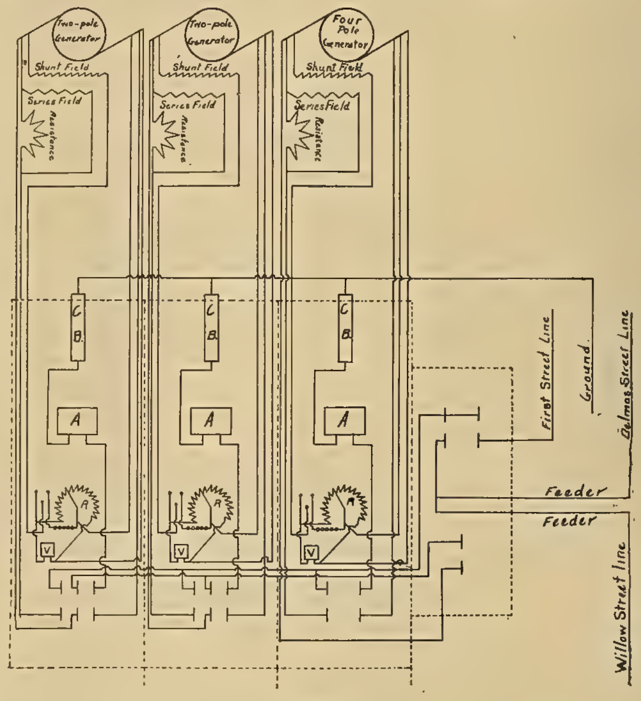
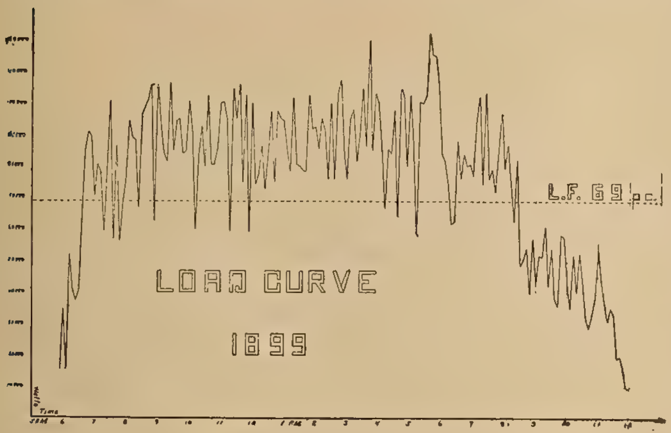


FIGURE 3.

out. This device has given more satisfaction than the second one.

The rolling stock consists of 26 motor cars and six trailers, and the three principal lines of the system have, respectively, six, four and two cars in the daytime and half those numbers of cars at night. The three remaining lines of the system are small ones, and each has one car in the daytime only. In addition to operating the street railway system the company furnishes a commercial power circuit in the business district, from which is operated elevator and other classes of electric power service, while out in the fruit districts, through which the railway lines run, it furnishes power from the trolley for operating a pumping plant for irrigating purposes here and there.



In an article which appeared in the "Journal of Electricity" for March last, the writer gave a description of the Monterey and Pacific Grove lighting plant as characteristic of the great majority of small electric lighting plants which are scattered through the Pacific Coast. Similarly this article may be accepted as a description which is typical of most of the electric railway plants in the small cities of the West. I believe such publications to be wholesome, as calling the attention of engineers to the possibilities for improvement in the character of the steam plants existing in most cities of the West, and in furtherance of this it may be stated that early during the present year an engineering concern of San Francisco made a report upon the plant of the First Street Electric Railroad Company of San Jose, wherein was proposed a plan of improvement in steam and electric plant guaranteed to effect a yearly saving of 33 1-3 per cent. in the fuel bill, or about $3,600 per annum. The engineering concern referred to moreover proposed to make the cost of such improvements contingent on the saving that they would effect, so that there would be no outlay on the part of the railway company, but thus far the proposition has not been accepted.

The report referred to contains some matters that may be of interest concerning the operative features of the plant, and the remaining portion of this article is taken from it.

Under test, the boiler showed an evaporation as high as 110 lbs. of water per cubic foot of wood from and at the temperature of the feed water, which is not given. The boilers were found to be in good condition. On January 9th last, a six-hour test was made to determine the steam consumption of the 250 horse power engine. Ten cards were taken between 8:30 a. m. and 2:00 p. m., the average of these cards being 183.499 indicated horse power, while the readings ranged from 165.58 indicated horse power as the minimum to 218.90 indicated horse power as the maximum. These cards were taken at regular intervals during the test. The feed water used was found to be 4,205.50 gallons, or 25,031.06 pounds, which is an average of 5,838.51 pounds per hour, which, reduced, shows an average of 31.82 pounds of water per indicated horse power per hour. The report states that the average load has increased by 45.39 indicated horse power between November 12, 1898, and January 9, 1899, "due to leaks and unknown causes." The friction losses in engine and countershaft are 20.43 indicated horse power, and the power consumed in station lights and line leakage is 9.74 indicated horse power. The friction load of the 150 horse power engine, shaft and armature was found to be 17.73 indicated horse power.

Proceedings of the Third Annual Convention of the Pacific Coast Electric Transmission Association, Held at San Francisco, June 20-21, 1899.---Concluded.

[Continuation from page 54, August number.]

We do not know whether the same result would come from asphaltum as we did not experiment on those lines; but we do know that what we did has proved highly successful.

Dr. Perrine: If paraffine pins are a good thing, why not carry it to the arms?

Dr. Van Norden: It is not needed. If you find the current will not go down the pin to the arm, what is the use of boiling the arm? You might say why not boil the earth, and put paraffine in everything. You must stop somewhere.

Dr. Perrine: Do you think your pins are better insulators than your glass insulators?

Dr. Van Norden: No.

Mr. Jones: In regard to boiling pins, cross-arms and poles, I have found trouble in boiling the long shanghai pins that give seven inches of space between the petticoat of the insulator and the cross-arm. The long shanghai pin is of great value over that of the standard Western Union size. I boiled a batch of pins in asphalt to, I think, about 250 or 300 degrees Fahrenheit. We used the locust, North Carolina pins, and quite a number of them we found so defective in consequence of the high temperature given while boiling that we did not dare to use them. They rotted from the surface to such a depth that it made them weak. In construction, we did not pull the wire as tight as usual; we found several pins that had angled ahead considerably toward the head guy strain. It was not due to tight wire at all. But as to asphalt, if we could find some solvent for it, and apply it heated not to exceed about 100 to 150 degrees Fahrenheit, and soak the pins therein without leaving too much thickness of the asphalt itself on the pins, it would be an excellent assistance to insulation. We have cooked all cross-arms and have cooked them "to a finish." It does not hurt them at all if large arms are used. Before cooking cross-arms and pins they ought to be kiln dried as completely as possible before they receive any insulating material on the outside. Utah gilsonite is a higher grade of insulating compound than asphalt by, I think, probably ten to one. You can apply a coating on a metal plate by dipping, which will stand test against 10,000 or 15,000 volts. I think I would drive the pins in the arms and duck the pins and cross-arms together in this solvent, and avoid, if possible, the use of iron braces. The high pressures we are reaching now in long transmission lines avoids the necessity of bracing as thorougaly as when we used the Edison three-wire system on 110 volts. We now get higher pressure, lighter wires, and possibly aluminum wire.

Mechanical strength is not required to such an extent as it was in the past; but as for insulation, I think we cannot get it too good.

Mr. Martin: I may be considered radical in my ideas of line construction, and I will illustrate it by the usual trick of the magician, who has a series of boxes, one within the other, all of which are locked securely in order to secure the contents of the smallest box. I am satisfied if a strong enough lock were placed upon the outer box there would be no necessity of having a series of boxes within each other to get absolute security. Personally, I pin my faith absolutely to the security of the insulator; so much so is that true that in the present construction of the 40,000-volt transmission line I have no braces and no treatment of pins, cross-arms or poles. I think everyone will agree with me that the greatest element of risk on a power transmission line of any voltage occurs during wet weather, and I doubt seriously whether any insulating material you may place in or upon your cross-arms or pins will prevent surface leakage during wet weather. We all know that dry wood is as good an insulator as we want; as good a preventive as we need in the matter of leakage from one leg of the circuit to another. The doing away of the braces was brought to my mind very forcibly by restricting the air gap between any two legs of a three or four wire circuit, which is absolutely true, and dealing in the higher voltages, and knowing something of the static spark which these high voltages produce, and of the air gap through which they will jump, I deemed it wise to remove anything that would bring those wires closer together, and we are therefore removing braces entirely.

I agree with some of the members that the question of the insulation of the pin is not a material factor. If our insulators are good let us depend upon them; if they are not good let us get insulators that are good. You have no insulation from the ground so far as the pole is concerned. You never think of treating the pole particularly. In one of the installations in the East they have iron poles for a 5000-volt transmission line which brings the earth right up to the cross-arm, and in that case they use no insulating compound at all, or possibly a little P. & B. paint. The experience I have had in the operation of 16,700 volts on the Marysville circuit has been this: Our poles were entirely untreated—they were natural poles with the sap; our cross-arms were painted with P. & B. paint; we used an iron pin which practically eliminated any insulation between the insulator itself and the cross-arm; and we have yet to see the first of our insulators to be affected, or any part of our pole line to be affected; and we have been in operation now seventeen months. I don't know of any better record than that. The line was tested by Dr. Perrine at 30,000 volts; I believe it was in April or May of last year. There was no trouble except where the lines were converging into a building where they reached a distance of six inches apart, and as soon as the increased potential was produced an arc would form, and, creeping out upon the line, would dissipate and reform and dissipate, causing short circuits on the line. We are gaining our poles a quarter of an inch deeper than customary. We do not find that seriously objectionable, because the weaker part of our pole is not at the top. We are depending upon our gain to keep our arms practically level. We are using one bolt right through the pole, and, assuming for argument's sake that at any time they may become one-sided, the hexagon cannot become seriously distorted, and if it were it would not affect the actual operation of the line. I think when we are trying to insulate everything from the wire to the ground, we are going to unnecessary expense; and while I may be mistaken, I am making the experiment, if you so please to term it, and I offer the prediction to-day that a year from now I will be able to tell you our 40,000-voltage line has been operating from the time of its starting until then without any troubles at all.

MR. SHARP. I have had an experience with 17,000 volts. We painted all around with P. & B. paint. The arms had iron braces and they gave no trouble. I would like to ask what kind of pins Dr. Perrine has been using.

DR. PERRINE. Wood.

MR. SHARP. We used a Locke steel pin with a wood thread. They are not treated with paraffine and give very good satisfaction.

MR. MASSON. My opinion is the same as Dr. Van Norden's, with the exception of the arm brace. I believe if you can get a good, dry pin, which does not absorb moisture and will keep the rain off, that you do not need any more insulation. I believe, as Mr. Martin states, if you have two boxes that one is sufficient if it is strong enough, but yet when you don't know about the one, we are accustomed to putting a lock on both, as with a safe when we put a combination lock on the outside and another lock on the inside. We do know that the first success we had of regular operation anywhere on the coast was when we commenced paraffining pins. I think that was the first radical improvement. We all know if the pin is kept dry both by the insulator and by the paraffine, not allowing the water to cling to it, that that is enough insulation for any voltage, perhaps up to 15,000, without the effect of the insulator at all; that is supposing it is a six-inch pin, I think six inches of dry wood from the wire to the ground will stand 15,000 volts, according to some tests that were made here. If that is the case, when we have got a good insulator and a good pin we have got a double protection, and the breaking of the insulator even by shooting, unless entirely fractured, will not allow the wire to become grounded. Mr. Jones said they had a wire even laid on the cross-arm and it did not ground, and we would be perfectly safe so long as our wire was attached to the pin. When you try to insulate the cross arm you are undertaking a serious task, for the top of the cross-arm is generally very wet, even if it is not a flat surface. When it rains there will be a large continuous surface of water on the cross-arm, and I believe when making the effort to keep the cross-arm insulated we are going farther than we can and do very much good. If we could insulate the cross-arm—I mean prepare it with any paint that would keep the water off of it—we would be doing a good thing, but even then I believe a greasy surface in the nature of paraffine is better than a paint surface which merely keeps the water from getting into the cross-arm and the absence of the braces must surely be a good feature.

Mr. Jones' statements about the three-pole lines, and all our talk about the cross-arm braces, go on the assumption that the troubles are developed between two insulators on the same pole. If two insulators on the same pole are going to give us trouble, we have few chances on an ordinary transmission line of three wires of having trouble at all, while if any two insulators on the whole sytem can give us trouble our chances are about as many times greater as there are poles, or 1200 times on a 30 mile line. If the pin, pole and cross-arm are all insulators, and the two insulators that break down are at the same point, then Mr. Jones' advantage of having the three-pole line is in effect, because the current has to go to the ground through one pole and back up to the other. In most of the troubles the current did not burn off one cross-arm or one pole, but burned two, and in the Central California experience it was two. They burned poles as far as a mile or two miles apart when their insulators gave way. That would point to the fact that while the insulators give trouble the braces connecting up the two insulators on one pole would be only injurious when the two insulators on that one cross-arm got into trouble at the same time.

DR. VAN NORDEN. We never had two on the same pole.

MR. MASSON. That is what I understand. It always went to the ground and up another pole, so that the cross-arm brace did not affect the trouble in the least, and the only reason I would leave off the cross-arm braces would be to save money. I do not believe on an arm less than five feet long that it is needed, and whether the two bolt holes are objectionable or not I have never had any experience or heard any statement. If they are objectionable, one might hold, but I would rather see two and still have a deep gain. Mr. Martin's statement about the strength of the pole is perfectly true. We don't need any strength there; I have never heard of a pole that broke within five or six feet of the top; they always break near the ground. So a deep gain is no objection, and we can hold the arm without the braces. They are an expense we don't need to have.

MR. LEE. Without criticising what Dr. Van Norden has said, I desire to ask for some information. We know very well that an ordinary glass tumbler put on top of a pin, if we could secure our wire to it, would be a perfectly good insulator. That being the case, there is no reason why the double petticoat insulator would not stand any operating voltage that may be used in that part of the country, so far as penetration is concerned, providing the arcing distance or petticoat surface is sufficiently great, the only thing we need to look to is the insulator. If the insulator fails then the electrical strain comes directly on the pin, and I would like to ask whether Mr. Van Norden considers that the pin, in wet weather, or even where it is protected, has high enough insulation resistance to withstand the working strain of 15,000 or 16,000 volts.

DR. VAN NORDEN. I can only say such has been the case.

MR. LEE. Don't you think it is due to the excellence of your insulator rather than to the pole?

DR. VAN NORDEN. I do not, for the reason all along the line we have these paraffine pins, three to a pole, and for a mile and three-quarters we have the small insulators. All the way up and down the line we have no pin charred or burned, and no arm burned, and if there is any trouble of that kind it comes from one of the other pins in the older circuit.

MR. LEE. That is to say, the pins not treated are the ones that break down.

DR. VAN NORDEN. They don't break down very often, because the line is thoroughly dried out, but once in awhile we do have one.

PROFESSOR CORY. My practical experience, personally, in the use of insulators on transmission lines is not very large. Simple laboratory experience is not, perhaps, of very great interest just now, in connection with electrical transmission. However, a few weeks ago, in the Los Angeles sub-station of the Southern California Power Company, I was present at some tests made for the benefit of the municipal officers of that city. You probably remember that the six wires from the generating station are brought into the city at a line pressure of 33,000 volts. One question which was to be settled was the matter of the danger to a fireman when fighting a fire, if, perchance, a stream of water was thrown upon the wires.

In order to show what would happen, a plain Oregon pine cross-arm with ordinary untreated pins was put in the substation. Two insulators, mounted upon two pins, were placed on this one cross-arm, about two feet apart. Each insulator was connected with a terminal of a testing transformer. The pressure was raised to about 66,000 volts and a spray of water was turned on the wires leading from the transformer to the insulators. Before the water was turned on, in an absolutely dark room, no light at all was shown at the pin or cross-arm; but as soon as water was sprayed the pin lighted up over the lower part and streaks of fire were seen along the cross-arm between the two insulators. This seemed directly to indicate that a wet, untreated cross-arm with wet, untreated pins, might show a considerable leakage. Incidentally I might say that the man handling the hose was in no wise inconvenienced, and declared that he received no shock whatsoever from the stream of water.

Later on another cross-arm was used, which, I believe, was treated with paraffine paint only, and upon which were mounted two insulators upon iron porcelain pins. The distance from the bottom of the insulator to the cross-arm was, as I remember it, about 4½ inches. The water was again turned on, after the pressure had been raised to 66,000 volts; and no leakage was noticeable whatsoever. In that connection it seemed to me to be evident that, when we come to treating pins, it is only a question of moisture. Very fine particles of water were noticeable on the porcelain pins, but there was no leakage.

In general, regarding the operation of the transmission line of the Southern California Power Company, I was told that the line had worked satisfactorily from the very beginning. When I asked, "What do you put on the cross-arm?" the reply was, "Nothing." This I was told by the representatives of the Company. I do not know exactly how long the line has been in operation; but I do know this, that climatic conditions in Southern California, particularly during the last year, have been very different, as regards moisture, from those surrounding some northern transmission systems.

MR. MARTIN. Is it not a fact that they use a steel pin on that transmission line?

PROF. CORY. An iron-porcelain pin.

MR. JONES. The use of steel pins for line voltages above ten or twelve thousand volts should be avoided. We once applied 11,600 volts to a line of pins bolted to the cast frames of transformers, the bolts being leaded-in to the interior of good porcelain insulators. The transformer frames were used as supports for the insulators, but I would not do it again for, while it caused no trouble, it is bad practice. On examining the line one night we found a "fire-fly" at the top of one of those insulators. It was a good "fire-fly," and Mr. McKee thought it would be wise to shut down the station and take out the "fire-fly," but I advised against doing so, and it remained. Mr. Blackwell and Mr. McKee slept that night in the transformer house on the second floor of the station building, and Mr. McKee got up a dozen times during the night to examine the leakage. The next morning it was the same, only not so apparent in daylight. That same "fire-fly" continued there for over two weeks before we had a chance to shut down or change the insulator, but we allowed it to remain for that time even though it was a dangerous, if not a reckless, thing to do. The transformer from the other leg must have been alive from the accumulation of dust on the insulator in order to have given the small current necessary to produce that amount of "fire-fly." I maintain, therefore, that in insulating lines the insulators themselves should be of the best. I don't mean for 10,000 volts, I mean for higher voltages than that, but for any excessive voltages the insulator should be of the very best that can be secured. Use long Shanghai wood pins which are well soaked and cooked—not burned—in some good insulating material, and treat the cross-arms after the same manner in connection with the pins after the pins are driven, and then use no arm braces. Some cases do not require such care, but all the dust that blows in a dry windy country—and there is a little mineral contained in the dust of a good deal of the high country—all the wood cracks and checks, and all the rain and moisture is bound to cause trouble if the line is not well insulated. It is possible to protect pins and cross-arms from checks, hence it is not detrimental if a continuous sheet of water is on the surface of the cross-arms. Twenty thousand volts is not very difficult to handle, but the higher you go the greater the danger. It is so between 10,000 and 20,000 volts but the difference is more marked between 20,000 and 40,000 volts than can be imagined until after the results have been seen and examined. Paraffine is an excellent insulator, but if it is heated to such an extreme temperature as that mentioned this afternoon it is bound to deteriorate the wood and make weak pins and arms. The pin and cross-arm should be absolutely dry when put in to cook—preferably when hot from the dry kiln. The cross section of the pole at the gain is greater than the cross section of the cross arm, and there is no danger of the pole breaking at that point; in fact, one-third of the pole could be taken out at the gain without detriment, therefore, iron arm braces are unnecessary unless the arms are longer than seven feet.

DR. VAN NORDEN. I should like to know whether it is necessary to asphalt the butts or poles.

MR. SHARP. In the Riverside line it was proposed to paint the butts entire with P. & B. paint to a point two feet above the ground, but I suggested that if such was done the poles would dry rot inside. The poles were then painted two feet above and two feet below the ground surface, and my personal experience is, that poles so painted give the best satisfaction, as they will not dry rot at the air line.

DR. PERRINE. This whole question has been thoroughly discussed before the Society of American Civil Engineers in a paper presented before them and a subsequent discussion, wherein was given not only the practice in this country, but also in Europe, the paper being historical as well as representing experience. The experience of a large number of railroad companies was given, and all the telegraphic companies, and they all hold that there is no value in coating the butts and poles if they are green. To the contrary, it is even possibly a detriment, and if the poles are to be coated at all, they hold there is no value of coating any except just the section about eighteen inches above and below the ground, and that the pole being thoroughly coated over the end forms a receptacle in which moisture accumulates and dry rot occurs. The same thing, I find, has been the experience of a number of post planters in this country with redwood. In every case where fences have been protected by tarring the butts of redwood fence posts, there has been, if anything, a lessening of life, if it is thoroughly coated to the end. That I do not give as my own experience, but as the result of a large amount of accumulated experience as given in the discussion before the American Society of Civil Engineers.

MR. VAN NORDEN. I would like to ask a question in this connection. I was recently advised by an experienced lineman to remove the earth around about the poles, two or three inches from the poles and a few inches into the ground, and pour a gallon of tar oil around it, so that the pole would be tarred just above and just below the surface of the ground, and then put back the dirt. Has any one experience upon this?

DR. PERRINE. That is one of the methods of treatment given in this paper I speak of. It is said to be efficacious, and it is, moreover, the only method that is held to be of any value. In France they set poles by enclosing them in split terra cotta pipe extending for a few inches above and below the ground line for eighteen inches or so.

MR. JONES. That is for the preservation of the pole itself at the ground line?

DR. PERRINE. Yes.

MR. JONES. I built a line in Evanston, Wyo., eleven years ago, using white Oregon cedar and California redwood poles, and last year I had a chance to examine the line again, and found that, while the outside surface of the redwood had been worn off, the balance of it was perfectly sound just above and below the ground line, where it wastes and wears away from the action of the weather. A portion of about ninety miles of white Oregon cedar pole line that I built in Salt Lake ten years ago was examined last year and found to be in good condition, which proved that the cedar had not rotted. These were sawn square cedar poles; the poles having sap were rejected in the original lot, and I imagine that sawn square cedar poles will last from twenty to thirty years in perfectly safe condition. The Bell Telephone and Western Union Companies have used very large round poles with the sap in the same locality, and after the poles had been erected narrow channels were dug around the poles from two to three feet below the surface and these channels were filled with rock salt taken from the beach. These companies contend that rock salt is the very best protection that can be given to the poles at the surface, but I don't know whether it is so or not. I do think, however, that while Oregon cedar and California redwood are all right without any preparation. In 1866 the Union Pacific Company built a creosote works in Laramie, where the tires required for 300 miles of railroad were creosoted. After the job was finished the plant was shut down, and the company has been waiting ever since to see whether creosoting ties is advisable. The question is whether creosoting increases life sufficient to pay for the cost of doing it. It is necessary in cooking wood in creosote to inclose it in an iron take under heavy pressure, so as to force the compound into the wood for an inch or a half or two inches. To do that to poles would take a sixty-foot cylinder under high pressure, and it is a question as to whether there is any commercial value in it to compensate for the expense. I don't believe there is. The poles are good when set originally as they were cut, but get good timber.

MR. SHARP. In Southern California there are two different plants in which the earth has been dug from around the poles for the depth of a foot or so, after which from one to two gallons of crude oil is poured in and allowed to settle and soak, when the earth is put back again and tamped.

MR. JONES. These methods are all the same, but none of us will live long enough to learn how long the poles will last under such treatment.

The convention then adjourned to the day following.

SECOND DAY'S SESSION.

The second session convened at 10 a. m., President Pce. A. Poniatowski in the Chair.

THE PRESIDENT. We will begin the session by listening to paper by Prof. Cory on "The Regulation of Alternating Current Generators."

Prof. Cory then read the paper reproduced as the leading article in the JOURNAL for August (Volume VIII, page 33).

DR. PERRINE. The point that Prof. Cory has brought out here so clearly seems to me to be very important. The importance of our line losses with an inductive load is very great. There is a great deal of talk about wattless current and inductive load, but the electromotive force consumed by resistance is always in phase with the current, and in consequence to supply an inductive load over a line consumes just as much power as though the current sent were supplying a non-inductive load. In this case I have forgotten the figures exactly, but the line on the non-inductive load, I think, consumes 33 kilowatts, and with the inductive load it is 51 kilowatts, and that with a power current only increased by about 25 per cent., namely, from 50 to 62 amperes. Take the case of starting a motor on an inductive load, you will have not the variation of the current by 25 per cent, but you have the variation of the current by 200 or 300 per cent, and sometimes four or five hundred per cent. Consequently, your line loss will vary from what you originally estimated to four or five times that amount of loss. Take a line built for ten per cent. C^2 R drop, and load that line full with non-inductive load, you have got ten per cent C^2 R drop in the line and ten per cent of your energy constantly wasted in the line. Now, substitute for that non-inductive load a motor of the same capacity, and let that motor take four times your normal current to start it, then the line drop immediately jumps from ten per cent. of your energy to forty per cent of your energy. And that is the reason that in some cases they find that this wattless current not only drops the voltage out of sight, but drops the water wheels out, and that is a matter that deserves a great deal of attention. In a plant in the East—I spoke to some gentlemen about it yesterday—they have a motor of abut 100 horse power which loads full at all times a 300 kilowatt dynamo, and the whole is figured for 300 kilowatts, but all they can run is that 100 horse power motor. It is a motor of such bad power factor that it takes full load current from the generator and brings the line loss up to the full load line loss with only one-third of the power. What happens when the motor starts I don't know, but it is a matter of exceedingly great importance. All of these experiments, and all the experience that I have been able to come across in connection with running lines, emphasize the fact that it is not possible to neglect the power factor at starting, for your bad power factor at starting does require such currents as consume a very large amount of energy over the lines.

In a solution of the problem due to F. G. Baum there is given a dynamo having a toothed armature with four teeth. The armature and fields have regular windings. Now take a tap off the armature circuit, and in the tap put a self-induction in parallel with a capacity. Then take a few turns of this circuit around one of the poles, and come back to the other side of the line. So regulate the self-induction and capacity that at normal speed the current will flow through this combination, as though it was non-inductive resistance; then the current will be in phase with the armature current and have exactly the same effect as the armature current at normal speed. If the speed drops, more current will flow through the capacity than through the self-induction, and you get a leading current through this, and the voltage will keep up. If the speed rises, the current will drop through the capacity and you will get a lagging current through this circuit and the machine will be undercompounded. So you will get constant voltage no matter what is the speed of the machine within the limits capable of being controlled by the size of the coil and the size of the condenser. For an increase in speed the self-induction will take the most current, and you will get a lagging current, and the voltage of the machine will drop off correspondingly, so you will still get normal voltage for an increase of speed. For a decrease of speed you will get a leading current, your machine will be overcompounded and you will still get constant voltage for variations in speed such as are capable of being controlled by the size of the capacity and self-induction.

Prof. Cory. How about the self-induction of the external circuit?

Dr. Perrine. That is altogether outside of this. It makes no difference what happens outside of that circuit at all, for a normal periodicity the current flowing through the circuit will be absolutely in phase with the electromotive force. Now, when the speed falls the current will be leading; when the speed rises the current will be lagging, and you have got a machine that is compounded for variations in speed.

Prof. Cory. I think it is practically impossible to build a condenser which will have any appreciable effect in overcoming the self-induction of an ordinary induction motor. I was once interested in determining, under certain circumstances, how big a condenser it would be necessary to construct to counterbalance the self-induction of a certain induction motor. I found that it would be necessary to build a condenser 60 feet by 100 feet by 80 feet. Now, we cannot do that. It is all right at high voltage and high frequency, but practically we don't have our motors running on such circuits.

The President. If there is no further discussion on this subject, Mr. Lewis A. Hicks will read the paper he has prepared on "Electrically-Driven Centrifugal Pumps."

Mr. Hicks. In presenting the facts of this paper, the detailed account of the experimental work may seem somewhat elementary to some of you. I trust you will pardon this because in my own investigations the nature of the data which has come to my attention in the form of literature on the subject has been so thoroughly unsatisfactory that I have endeavored to make my own statement of conditions so clear, step by step, that there will be no gaps in the conclusions so far as the experimental observations go, due to unstated conditions.

These curves are of no particular interest, perhaps, except that theybring out some interesting conditions in regard to the changes in the power factor and efficiency of the motor, due to increase in voltage; but, of course, for the purpose of this experiment they are very important, because it was necessary that from the start to the finish of the test I should be personally cognizant of what we were doing. I saw no other way of doing that than by making the friction brake test, which amounts to rating the electrical instruments used.

I want to call your attention to the fact that the efficiencies shown by this diagram of the various forms of runners delivered to us for testing ranged from 68 per cent. to 63 per cent., while the efficiency of belted pumps of previous installation were from five to fifteen per cent. lower than the vertical type tested; so we made a net saving, and although we had specified only 50 per cent. as the lowest limit to the contractor, we actually obtained from 65 to 68 per cent.

The paper on "Electrically-Driven Centrifugal Pumps," as appeared in the initial article in the Journal for July (Vol. VIII, page 3) was then read by Mr. Hicks, after which an adjournment for luncheon was taken.

AFTERNOON SESSION—SECOND DAY.

The President. We will now take up the discussion of Mr. Hicks' paper.

Mr. Gilbert. We were about to install a centrifugal pump driven by an electric motor, and very much to my astonishment the pump manufacturer informed me that there was a critical point in the head under which that pump would act, at which the motor might become overloaded, that point being, as he had fixed it, considerably below the maximum lift of the pump. It struck me as absurd. I afterwards learned it was not absurd, but it had certain limitations. If that gives you a clear idea of the case, I would like your idea as to whether that point exists.

Dr. Perrine. I would like to answer that question. I think it is answered very clearly in the diagram. The point came up a year and a half ago as to whether we would not burn out a motor if the head dropped off. As Mr. Hicks read his paper I was watching this diagram to see if that point came out, because at the time of the meeting we had, Mr. Cobb and I afterwards consulted Prof. Hoskins, Professor of Hydraulics at Stanford, and none of them could answer it. They said it needed experimental information. I think Mr. Hicks has given it to us. I would like to answer that question as it appears to me from the diagram, and see if I am correct. Here we have the curve of the discharge with a varying head. The discharge increases as the head falls off up to a certain point, when it becomes almost practically constant, and at the same time we have a curve of the useful work. If the pump is normally operating at this head, say 110 feet, which is this point on the curve, and the head falls to 98 feet, you will get a little over one-third more work called for by the motor, but if the motor is operating when the pump is operating at its maximum efficiency, that is, almost the point practically of maximum work, and if the head falls off, the work will fall off, but if the pump is operating at lower than its point of maximum efficiency, it is also working at lower than its point of maximum work. So if the head falls off, the work will increase. In the case of this pump the work would increase to about one-half times the work it was doing previously, that is to say, at 110 feet the work is delivering 10-horse power, and it is also using an equivalent. Now, at 100 feet it is using 15-horse power, and at something like 98 feet it is using a little above 15-horse power, so the work would go up one-half times, but if the pump was working at its point of maximum efficiency then a fall in the head would mean a decrease in the work rather than increase. Am I right on that?

Mr. Hicks. That is correct as applied to the useful work and substantially so with regard to the mechanical input. Mr. Gilbert's question is further answered by the fact that this theoretical work curve has a maximum value at two-thirds of this height, and by no possible combination of circumstances could the useful work have a greater value at a lower head. The mechanical input might still continue to increase slightly after the useful work commenced to fall, as was true in this case, as shown by the tabulation, but in any case it would be very slight after the work curve reached its maximum, and with the load curve falling off rapidly must quickly commence to decrease.

Mr. Gilbert. But the load could be considerably greater than the load upon the maximum lift, so that a motor working under a full head might not have a maximum load.

Mr. Hicks. It is answered in this way, too: The horse power going into the pump at no discharge—at 120 feet lift with no discharge—amounted to 24 horse power. Now, at the next point of observation below that, where we had 203 gallons of discharge, the horse power was only 27; in other words, to produce 203 gallons discharge only required three-horse power, and the maximum horse power actually required to be delivered by the motor at any height of lift was 38½, and on the lower end of the load you will see how that runs down; instead of running back to 24, it only gets down to 31; that is to say, along in here where the discharge is practically constant your power is about 31 horse power, while your maximum horse power is about 36.

Mr. Gilbert. Perhaps you can answer the question in a more general form. We will assume that a motor discharging say, at thirty feet the head, was working to its full capacity, through some change in the water level that head may drop to 20 or 15 feet, would the motor then be overloaded, or would there be any point below the maximum lift where the motor might be overloaded?

Mr. Hicks. It would be utterly impossible, because as I have suggested just now, the maximum useful work would be at the height for which the runner was speeded, and if the motor were not overloaded at this point, any slightly increased demand on the motor at any lower height of discharge could not be regarded as a serious overload, to an induction motor. Does that answer the question?

Mr. Gilbert. It was through Mr. Barbour that I had the discussion with the manufacturer. At that time he took the part of the manufacturer. I used practically the latter part of your argument against that idea, claiming it was impossible.

Mr. Barber. It seems to me Mr. Hicks' argument shows that the contention of the manufacturer was wrong at that time.

Dr. Perrine. If the manufacturer rated the pump at a greater lift than the maximum efficiency, then the pump might overload, might it not? that is, the maximum lift, or the lift on that pump to a maximum efficiency is about 88 feet at that speed. If they should rate that pump at that speed for a 110 foot lift, then a fall to 98 feet would call for more work in that motor. Now, do they ever rate them that way? Do they rate them at a higher average than a maximum efficiency?

Mr. Hicks. They rate the pumps as though the periphereal speed had a constant relation to the head, regardless of form of vane used. This is absolutely incorrect; that is to say, the facts shown in the paper and the various experiments quoted indicate that this relation is variable, and varies with the shape of the vane. A proper speed rating of any pump can only be obtained by making the actual experiment with that pump, and finding out what speed is required to raise the water to a given height; in other words, the value of K, which varies from 400 to 800, must be determined by experiment, or known for the form of vano used from previous experience, and the pump may then be properly speeded for the height of lift desired, and its economical discharge, by the formula:

$V = K\sqrt{ch}$ where V = peripheral velocity in feet per minute; K = a coefficient depending on the form of vane and to a slight degree on the height above sea-level; C = a coefficient representing the ratio between the actual lift h and the hydrostatic head H created by the runner at a velocity V with no discharge.

The value of C as observed varies from 1.25 to 1.33, and might under ideal conditions approach 1.50. The manufacturers' standard speed table will not usually enable you to speed your pump correctly to obtain the best efficiency for the given conditions, because it is only applicable to one set of conditions You may find it best to run 10 or 15 per cent. slower or faster than indicated in such tables. This points to the necessity of careful adjustment of runner diameter to required work where direct connection to constant speed motors is contemplated.

The Chairman. We will now listen to the paper of Mr. Hutton.

Mr. C. W. Hutton then read the paper entitled "By What Method Shall be Determined a Fair Return for Current Supply," appearing on page 15 of the Journal for July.

The Chairman. Gentlemen, have you any questions?

Mr. Martin. To start the discussion, Mr. President, it has occurred to me that while we object to the cost of the ordinary recording wattmeter of this day, the many complications and different types submitted by that paper would make us very weary indeed. The problem, as submitted, is rather ingenious if we can carry it out. A great many plants are already started on a basis which are very difficult to change. The idea of determining a fixed minimum charge is a very good one. The fixed charge must necessarily change as your load increases or decreases, or as your expenditures increase or decrease, and in that way you would have a constantly changing rate which might never be satisfactory to the customer, particularly if you were unfortunate enough to have a much greater increased operating expenses, and depreciation without any increased benefit to the customer.

The Chairman. Mr. Gilbert, what is your idea about it?

Mr. Gilbert. I had expected from the title of Mr. Hutton's paper that I could offer some criticism on it, but I must say he has covered the ground so completely and ingeniously I can say very little in addition to it. I must say that the scheme is very pretty from a theoretical standpoint, and from experience with customers, dealing with them under competition, I would not like to take up the subject without studying it more carefully, but there are many ingenious suggestions that might be very valuable. It is a paper that should be studied before criticism. I would like to hear from Mr. Van Norden.

Mr. Van Norden. I am reluctant to express any snap judgment in this matter. The paper involves a good deal of intricacy, and I want to read it carefully There are one or two little things I can certify, though the paper seems to me to be admirable in its method and spirit, and I have no doubt the suggestions are extremely valuable, and will prove so on close study. But one or two little faults I am inclined to find with it. One is the very large expense of the proposed plant. I don't see why we should require $800,000 to develop such a plant as is described in the paper. I am sure it could be done for one-half or less the money, so that part of the calculation based upon that estimate, it seems to me, cannot be correct.

Mr. Gilbert. Would not that be purely relative?

Mr. Van Norden. I suppose so. As I say, I have very slight criticism. Then, with regard to the cost of light, I was not aware any company ever sat down and estimated what the custom ought to be, but I find as a rule they get all they can, all they can safely charge and collect, and in case of competition they get sometimes a good deal less than would cover the interest on their investment, and so on. We are governed entirely by the situation. Take our situation in Sacramento, for instance. We cannot get more than so much. If we attempt to, the business goes to the Folsom company, and they cannot get more than so much, or the business comes to us; and it is very difficult to make any arrangement that is legal, and that would be binding, by which you can entirely eliminate the element of competition, and arbitrarily fix the rate on some principle that seems just or possible to the parties selling power. I am strongly inclined to think our present method is the right one, that is to charge a rate that will give us a fair return on our investment, is what we consider good business, but make the rate as low as possible, and, we think, that by the low rates we have in Sacramento, and they are probably the lowest on this coast, that we have very greatly enlarged and extended our business. Sacramento is not a city of great wealth; there are a great many poor people who live on wages, and have little homes that they like to have well illuminated. The stores, as a rule, are not very large, nor do they represent a great capital, and the reason it is the best lighted city on the coast is that the rates are so low. There is plenty of power in the mountains, and perhaps we will never come to that point, but if we should the best thing would be to establish a meter rate. That would lessen the business somewhat, and would free a great deal of power, but we would get as much for the smaller amount of power, and in course of time we would sell the balance of the power. The next thing would be a storage plant, but the meter arrangement should come first and then the storage plant. That is, supposing we have a limited amount of power which cannot be increased except at great expense. I don't see any reason why we could not have 10,000, 20,000 or 30,000 horse power in Sacramento at a reasonable rate. I know I can bring power to Sacramento, the amount of power mentioned in the paper, at half the sum of money mentioned. So that whether we ever reach the point where we have only a limited amount of power, and must make the most of it or not, I don't know, but I am quite confident that in the present situation our plan is the best one, a low rate, and, as a rule, a flat rate. Some of our customers insist upon the meter, but they generally give it up and go to the flat rate. At first it is abused—badly abused. It is always abused by some people, not many, but in the course of time the great majority treat us pretty well.

Mr. Hutton. I would like to ask the doctor one question supposing that he had a certain number of kilowatts of hi plant allotted to supply a certain service, and that he found after furnishing them on the basis of a flat rate that he was fully loaded, and something would have to be done in order that he may carry more customers, whether he would consider the proposition of buying more transformers, increasing his generator capacity, rather than resorting to the use of meters. He says there is unlimited power. That is undoubtedly true, but it seems to me a few dollars spent in meters, and being able to supply more people in that way, would be better than to buy more machinery.

Mr. Van Norden. Of course, when we put on a meter we restrict the comfort of our customers; they don't enjoy the light as they did before, because they are always economizing.

Mr. Hutton. According to the method I have given you there, a customer can use as much as he pleases.

Mr. Van Norden. That is an excellent method. I am not criticising it at all. I simply want time to think it over.

Mr. Jones. This question of rate for power is a more important one with us than any other feature. We find little difficulty in producing and distributing power, and but little more difficulty in selling it, particularly where the customers are large mines and mills, and the power is to be used in mining and milling work generally. The managers of these properties all belong to the club; they get together regularly and talk; they compare rates with one district and another, clear back to the Niagara Falls; they talk about Portland and Montana rates, and rates in California, and they will not consider that the difference in the value of the power entitles us to any more than is obtained in some other localities where power is produced cheaply. In most of these districts coal transportation is expensive, and in other cases water for boiler purposes is very expensive. The contract which we have so far made in every instance has been either on flat rate or by what we term milled tons. In milling, concentration works, or cyanide works, it is very easy to get at the milling ton problem. They run night and day as long as their mills are in condition to run, and it is not difficult to determine about the amount of power each of those mills is using. After determining that, it is more practicable to apply a mill-ton rate to that company than a meter rate. If we were to-day to meet some of our customers on a rate of one cent. per kilowatt hour, they would turn us down, because the leading mining men of the country confer with each other on their ability to produce power at a very low cost. Many of them are not competent men in the power business; they have never measured their power; they usually consider they are using twice or three times the amount of power they actually consume, and they call it robbery to apply a recording wattmeter measurement to them, even though we give them a very low rate. The lowest rate we have ever offered was a service charge rate, based upon the capacity of the motors installed; that rate was $30, and for the power they used one cent a kilowatt hour. The largest portion of that mill is run only eight hours a day, hence the load factor is too low for us to supply.

The question is how can these things be accomplished? How can we get the customers, and still make a little profit out of the sale of the power? With the Golden Gate Mill this rate would be an elegant rate, and could be reduced, because they have between six and seven hundred horse power in motors installed in the mill, but the uniform power is between three and four hundred. The service rate would give us a good capacity of power. Their power is continuing twenty-four hours, but the majority of the mills use power but eight hours or twelve hours for certain departments, and in other departments the same works continue twenty-four hours the entire year, but the rates which we can charge and get to make a profitable business is the only difficult problem we have. It seems to me, from what I have gathered by conversing with the different members here, that the California rates are exceedingly low; I don't hardly see how they can do it. I hope our Mormon brethren will not say much about their rates while in California. I would like to learn more particularly what rates are charged by the different companies here in this country if it is possible to do so. If I cannot get it otherwise, I will have to get it "on the side."

The Chairman. It does not seem there is a very great difference between the rates charged by the different companies.

Mr. Jones. They are nearly the same, do you think?

The Chairman. I should say so. Take flour mills from north and south, I know two or three different companies giving power; the rates are very nearly the same.

Mr. Van Norden. Is it because it is the same flour mill?

The Chairman. Take traction; you see the street railroads in San Francisco, Los Angeles, Portland will have very much the same rates.

Mr. Jones. Do you refer to the continuous twenty-four hour service?

The Chairman. Eighteen or nineteen hour service.

Mr. Jones. At about what rate would it be?

The Chairman. We cannot very well disclose our rates here; every contract is a special case, and we have to meet each time different needs, but although the form and the conditions of the contract may bring about very material changes for us, our clients, as a rule, end by obtaining power at almost the same prices.

Mr. Van Norden. I have in my desk a list of the prices of all the lighting companies on the coast. It was correct, perhaps a year ago, but I don't know that it is correct now. I have not recently verified the figures, but the rates were very much higher than those that prevailed in our neighborhood, and there is very, very great difference in the rates.

The Chairman. We nearly all have the same ways of charging. We will make a charge per lamp, and when the customer uses a great many lamps we give him a large discount. A man having fifty lamps or one hundred or two hundred has large discounts. It seems to me that the small consumer of four or five lamps—a man will never get six or seven lamps, he stops at four or five—is the kind of a man who uses gas for ten years after electricity is in the town, and it would be in this direction that the load would be really increased to the greatest advantage, because in a town like Stockton, Fresno, San Jose, and others, are seen a great number of people still using gas, because they say the price of electricity is too high for four lamps. As a rule you only give discounts for large units, and in the smaller towns, after ten or twelve customers are taking electricity, the growth ends, and it will stand there for ten years. To get at the little customer you must have a low rate per lamp, because then you can go from one to two thousand lamps—you cannot get farther than 2000 lamps in some towns. The customers you want to get are those who will change from gas to electricity—the customers consuming two or three or four lamps per head—and their rate is, say, 15 cents, while the rate for the large customer is down to six or seven cents. I don't know what the rates in Sacramento are, but it seems to me it is the best town for electric lighting in California.

Mr. Van Norden. Electric light is cheaper there than kerosene, a great deal.

Mr. Martin. I had a peculiar experience in a small way in regard to the charge for meter service. One of our small patrons had a tank for irrigating purposes operated by a two-horse power gasoline engine, and we installed a one-horse power motor, with the understanding that no power was to be used during the lighting period or during the night time. The party objected to paying on a meter basis, our rates for small power being practically five cents per kilowatt hour. We put a wattmeter on to determine what was being consumed in one month, although we had agreed upon a flat rate of $2, and we found that we were getting 28 cents per kilowatt hour at that rate for the actual service.

There is quite a difference of opinion in respect to rates. Some plants are more favorably situated than others. There have been a number of installations through the United States which have been made unwisely. Some people thought that all they had to do was merely to post a notice up on a stream, and that made an electric power plant. They did not stop to consider the element of cost or the element of investment per horse power. Some plants are heavily burdened with bonded debt, and it is with those companies the greatest trouble is experienced. You take a plant with an investment of $100 or $150 per horse power installed. That company sells an average of thirty to fifty per cent. of the installed power, and they can very profitably dispose of it on a basis of one cent per kilowatt hour in large units; but when you reach the point of three, four or five hundred dollars per horse power installation you are then loading yourself with fixed charges, which are abnormal to start with, and you cannot expect the consumer to purchase power from you when he can produce it cheaper from another source.

Mr. Hutton. There is one further remark I would like to make about the curve in my paper. The curve is a theoretical curve of the cost with a given amount added to it; that is, the interest, depreciation, and so forth, which is also supposed to appear in the dividends. The length of the perpendicular lines at any point indicates what you could afford to sell that current at and still be on a paying basis. At a certain point, if I could sell all the power I had for twenty-four hours a day, thirty days in a month, I would charge on the basis of a customer using one kilowatt connected and running twenty-four hours per day, thirty days in the month. This would use 720 kilowatt hours in a month, and I would have to charge him that fixed charge of 3½ per kilowatt plus seven-tenths of a cent per kilowatt hour. If my average was only, say, sixteen hours, that would change the situation, so that if the customer used current on an average sixteen hours a day, thirty days in a month, I would still have to charge that three and a half for the fixed charge, and as they would use 480 kilowatts a month, I would have to have a little bit high rate per kilowatt hour, so adding this to the preceding would make my total fixed expenses, which, in the case cited, would be nine-tenths of a cent. As you advance along here it simply goes to show that customers who use the current for longer hours during the day, the rate keeps dropping, you can afford to make them until you come way up here. Suppose you have a plant loaded down, and they only used it for two hours a day, you would have to charge them on the basis of six to nine-tenths cents per kilowatt hour, and three and a half for every kilowatt connected. In any plant you can take the corresponding figures, and it will always show you what rate you can afford to make per customer, that burns a given number of hours. In other words, take a customer who if he is going to burn, say, four hours per day, here is given the rate you can afford; and if you have customers who are going to run twelve hours, here is the rate you can afford to furnish them. There were four classes of customers spoken of, and one of them was the class we would get from the pumping plant along the line. As I said before, they would have nothing to do with the peak load, and what revenue we would get from them would be clear gain, because this curve is plotted on the basis of the peak load. In the case of a short-hour customer it would climb up so high he could not afford to pay the rate, and there is always a good income from those people, and we gradually drop that rate, but we will have to put a little bit more onto these fellows down here that burn from four to six hours a day. In the case of the Sacramento plant, I should judge that fully ninety per cent. of our customers would use one kind of a meter, that would be the meter I spoke of, which would indicate the customer's actual demand, and if he wanted to he could push the button and add more. Then there would be the other class of customers who use power for long hours, and for those that want to install a maximum demand indicator, and you can have that made in the form of a wattmeter, and you would be serving two kinds of customers with wattmeters, which would be identical, and the other class would be furnished by another kind of a meter with a slight modification.

The Chairman. The peak load seems to be always in the way. I think this Association should be fully enlightened as to what can be done with a large system of storage batteries at the terminal of transmission lines so as to get around the peak load. It seems to me that it will be possible to have a plant sending a constant current twenty-four hours, that is, sending the average load and having the storage take care of the peak load; a uniform rate per K. W. hour, regardless of the peak load, will then be the best, and under such conditions of service a good price can be obtained.

Mr. Hutton. One thing that is particularly against flat rates is, that the customers will waste the light; they waste the power; they don't turn them off when they should, and the result is in our case in Sacramento we have a peak load four and a half hours wide, and a storage battery is out of the question, you could not do anything with it.

Mr. Gilbert. The Sacramento case is peculiar. That wide peak occurs only a few months in the winter.

Mr. Hutton. I have a curve here which shows the residence lighting alone, and that peak is four and a half hours wide entirely lighting.

Mr. Gilbert. For an average for a week or one day in the week?

Mr. Hutton. This is for an average of days.

Mr. Gilbert. That is a flat rate.

Mr. Hutton. Yes, the peak load reaches the maximum at half past five, and falls off gradually until it has only fallen off about ten per cent. at half past nine.

The Chairman. I wish to say a few words before closing this session: The benefits derived by all of us from this Association are evident, but I believe that they can be materially increased if you help me to successfully carry through the following program:

Instead of an annual session, such as we have just held, I propose to organize during the year a series of monthly meetings of less magnitude, but which will keep us more constantly in touch with each other.

My main objection to annual sessions held by any organization is that I do not believe that it is possible for unprepared critics to get up and discuss with intelligence a series of eight or ten papers, which have been the object of serious consideration, and two or three months' work on the part of their authors. Don't you think that we will do better in obtaining a communication from some interesting source on one subject at a time, the same being printed and addressed to every member of the Association on the fifteenth of the month; an informal meeting to take place in San Francisco on the last day of the same month, when every one of us could bring to this meeting notes and data concerning that one subject after fifteen days of possible study?

I will go further and say that I really think we would derive still greater benefit by obtaining such papers from other sections than California. For instance, we might obtain from the best constructor of hydraulic wheels in Switzerland, a paper on their most recent designs or application. And I think that such papers can easily be obtained if, in return, we agree to send to their authors a copy of the report of our discussions thereon, so that they will thus obtain a most interesting appreciation of their own work, furnished by ten, fifteen or twenty authorized critics with whom they could not otherwise communicate.

This is only an outline of the policy which I believe your Executive Committee should try anyhow. You may object to this on the ground that very few of you can come to monthly meetings. I will say that all those within a reasonable range of San Francisco have to come to San Francisco at least once a month, and would very likely make it an object to come on those regular dates. For those established in the far North or South, they would receive a copy of the paper on the fifteenth, and could, without much work, commuicate in writing their observations so that the same could be read and spread on the minutes; also, a copy of the minutes of each meeting would be addressed to every member of the Association, so that each month those not present at the discussion would anyhow be informed of its proceedings.

Annual meetings give to any association a nominal vitality, but the intrinsic value of the work accomplished at such conventions is, in my judgment, the lot of the eight or ten men who have prepared the papers. Of course, some new accomplishments may be brought forward at such conventions, but this is seldom the case with the present speed of development in electrical art; and any new accomplishment cannot be bottled up for four or five months, and, if of any great interest, has to be spread at once. Our monthly sessions would keep us informed while we need such information, and not eight or ten months afterwards.

It will certainly take your Executive Committee during the coming summer to organize this new plan and obtain the proposed papers from the outside, but I think that from October on we will be in shape to inaugurate this new system for which I ask your hearty support.

On motion, the meeting adjourned.

Those who are desirous of securing information concerning the rapidly growing mining interests of the Kootenay district would do well to secure a copy of the July Annual of the *Kootenay Mining Standard*, which is a well-illustrated and very readable special edition of the leading mining paper of that portion of Canada.

Correspondence

THE GREEN-HOWARD GAS CONTROVERSY.

Within the last month considerable attention has been devoted by the San Francisco dailies to the action brought by Willard R. Green against one known to many prominent San Franciscans as Augustus Howard, or by his racing associates as "Plunger Hill." Many important details of the operations of Mr. Howard have been brought to light through scores of columns in the daily press, yet the circumstances which were really instrumental in deciding Mr. Green to take action against Mr. Howard have so far been known to but a few.

It has already been stated in the San Francisco *Call* that Mr. Green met Howard in September, 1897, and subsequently became interested in a process by which, it was represented, one could produce a gas possessing all the desirable features of acetylene, with many of its undesirable ones eliminated, and at a cost such as would make it marketable for purposes of illumination.

To effect this has been the aim of some of the brightest chemists of the day, and has involved the expenditure of enormous sums. To one who had successfully promoted gigantic business enterprises, the value of this proposition was at once apparent, and with a full realization of the magnitude of the venture, Mr. Green spared neither pains nor expense to fully satisfy himself as to the correctness of Howard's assertions. Retorts were constructed and furnaces erected in such a manner as to apparently preclude all chance of deception. The ingredients were entirely furnished (supposedly) by Mr. Green, who witnessed the proportionment and subsequent mixture. The introduction of the mixture into the retorts, the subjection to heat, the removal of the product (a solid material resembling calcium carbide), and the production of a gas therefrom (said to resemble acetylene), were conducted openly. Mr. Green even took further precautions by compelling Howard to so instruct him in all the details of the process, as to enable him to successfully bring about the same results.

By way of explanation, it might be said that acetylene is formed by the decomposition of calcium carbide by water, chemically expressed by the following equation:

$$\underset{\text{Calcium Carbide}}{Ca\ C_2} + \underset{\text{Water}}{(H_2\ O)_2} = \underset{\text{Time}}{Ca\ OH_2o} + \underset{\text{Acetylene}}{C_2\ H_2}$$

It is but necessary to employ any of the many forms of generators by which calcium carbide ($Ca\ C_2$) is brought in contact with water to generate the gas acetylene, which gives, when mixed with air in proper proportion and ignited, a light of at least some 250 candles, with a consumption of 5 cubic feet per hour.

Calcium carbide is a dark brown substance closely resembling coal, and presenting a fracture very much like that of cast iron. It rapidly whitens on exposure to air, becoming covered with a film of lime. It is manufactured from lime and coal, the first supplying the calcium and the second the carbon, which unite only at a high temperature such as may be obtained by means of the electric arc.

Many forms of electric furnaces have been devised, but the cost of production is yet such as to prevent the substitution of acetylene for illuminating gas, even were there no other points to be considered. With its high candlepower however, it is quite evident that a process effecting a considerable reduction in the cost of the carbide, together with an elimination of the undesirable properties of the gas, would possess almost unlimited value.

It was advanced to Mr. Green, and seemingly proven, that the cost of the solid material resembling calcium carbide (Howard claimed the material to be other than carbide and the gas to be other than acetylene) could be reduced to such a figure as would allow of the production of a gas, equal in candlepower per cubic foot to acetylene, at the cost price of ordinary illuminating gas.

After a thorough research, involving the assistance of well-known experts, who reported favorably as to the gas, Mr. Green negotiated for the rights offered by Mr. Howard. As the use of

(Continued on page 82.)

THE JOURNAL OF
ELECTRICITY, POWER AND GAS

Devoted to the Conversion, Transmission, and Distribution of Energy.

Conducted by GEO. P. LOW.

Official Organ of the Pacific Coast Electric Transmission Association.

Yearly subscription: Domestic, $1.00; Foreign, $1.50, postage paid.

Entered as second-class matter at the San Francisco Post Office, August 15, 1899.

Entered as *The Electrical Journal*, July, 1895. Entry changed to *The Journal of Electricity*, September, 1895.

Published monthly at 320 California Street, San Francisco, Cal.
Address remittances and communications to
315 CHERRY STREET, [Telephone, "Pine 76"] SAN FRANCISCO, CAL.

VOLUME VIII SEPTEMBER, 1899 NUMBER 3

For Table of Contents see Page XI.

EDITORIAL.

POLYPHASE ELECTRIC TRACTION.

It is hard to understand why electrical engineering in Europe has attained a higher plane than it has in America in the application of polyphase currents to electric traction, unless it be that the use of direct currents for the great urban cities of this country has been attended with such pre-eminent success that our own engineers have for the time being overlooked serious consideration of the advantages that would accrue from the development of any system of electric traction distinctly applicable to long-distance railway lines. It can not be said that the perfection of the direct-current street railway system has absorbed the entire energies of American electricians, for it is evident that they have found it possible to at least hold their own in other channels of engineering; but perchance it may be that the working out of the infinite details attending the solution of street railway problems in large cities has exercised a subtle influence which has tended to so engross the attention of American engineers that they have unconsciously adjudged the limitations of electric traction to be encompassed by direct current applications. But if the glory for the development of the direct-current railway system is our own, we must certainly and gracefully concede that the credit for the first development of the polyphase system of electric traction belongs to our European fellows.

Of course the engineering departments of the great manufacturing concerns are fully cognizant of the general progress being made in each and every line of electrical work beyond the Atlantic, but it is not to be expected that the great companies will devote their energies to the solution of polyphase traction problems until a demand has arisen for equipments of that nature. Given the demand and the equipments will be quickly forthcoming; but at present that demand, so far as the Pacific Coast is concerned, seems remote, for the question of polyphase traction is one of population and commerce rather than of technical detail. Develop commercial feasibility first and electrical and mechanical feasibility will soon follow.

⁂

It is a pleasant day dream to soliloquize on the beauties of polyphase traction while the heavy train laboriously climbs the Siskiyous with the energy of the Sacramento river idly wasting beside the tank; or while a heavier train crosses the Sierras with the water powers of the Yuba on the west and those of the Truckee on the east; or again, to see the mightiest locomotives of American build struggle with the grades of the Tehachapi while from the waters of the Kern not far distant could develop sufficient power to pull a dozen such trains with ease. Similar conditions exist along railway lines traversing the Rocky Mountains and Cascade ranges, but be it remembered, that everywhere, the modern locomotive is altogether a very efficient mechanism; that coal in an engine's tender at any point on the railroad by no means represents the market value of coal in that locality; that trains in the West are, as a rule, so provokingly infrequent that, all things being considered, the load factor of any traction plant covering a hundred miles or so would almost defy discernment. Surely then, electric traction offers no inducements for climbing the principal mountains of the West.

Take other instances, such as between Tacoma and Seattle, between Salt Lake City and Ogden, between Port Costa and Oakland, and beween San Francisco and San Jose, where trains are running at all hours of the day and largely through the night. These instances, and particularly the two last named, might be proven to be an attractive field for the introduction of electric traction; but even so, it is doubtful if polyphase traction would now be the preferable. The distances would be from thirty to eighty miles or so, and some very nice questions would arise in making a choice. Were the service to be of local character — that is with frequent stops — it can hardly be doubted but that the direct-current system with rotary transformers feeding into the trolley line at intervals would be favored by American engineers were their opinions not influenced in the opposite direction by the absurd price to which copper has now risen. Under present conditions therefore, it is probable that were electric traction to be installed between either of the points named, the trains would be equipped with polyphase motors even though the service to be performed would be of a local nature. On the other hand, were the trains to make through runs, requiring only one starting of the motors during a single trip, the line would unquestionably be of the polyphase variety.

Again, take the case presented at the Oakland pier where the Oakland, Alameda and Berkeley locals come and go almost half-hourly during eighteen hours of each twenty-four. The conditions imposed are: heavy trains, quick starts, brief runs and short stops — a class of duty that only direct-current motors can perform with the degree of economy in operative and installation costs which investors would exact of electrical machinery. For instance, were induction motors installed in electric locomotives for the Berkeley locals to take the place of the "double-headers" now used afternoons, where would the power factor be in starting the train with an acceleration which taxes the two steam locomotives seemingly to their utmost? Consider too, that this dose is administered to the generating station each and every time a local starts on either the Oakland, the Berkeley or the Alameda lines, and that the chance starting of two of these trains simultaneously will double it, and one will realize that the generation station must have an unassailable constitution to withstand these undermining draughts. Polyphase traction has no place on the Oakland mole today, but the developments of the tomorrow of electrical engineering may enable the telling of an opposite story.

⁂

But what stands in the way of making polyphase traction immediately available? In answer one may say in general terms that the obstacles to the adoption of polyphase traction rest in the inherent idiosyncrasies of the alternating current and alternating-current machinery. At times alternating-current phenomena are so startling that engineers in other professions cannot but regard them as fantastic theatricals; for there is nothing more eminently qualified to sorely "tax the capacity of the human understanding and alternating-current generators" than the considerations involving lagging and leading currents, self-induction, capacity, power factors, starting currents and torques and other functions which the schoolboy would generalize as "too numerous to mention." Ultimately the problems involved in polyphase traction will be resolved into methods for automatically restricting the voltage and current to the narrow path of coincident wave relations, but in all probability before this is done the efforts of builders of polyphase roads will be directed to increasing the starting torque and decreasing the starting current to the greatest possible extent, and relying on ample prime-mover, generator, transformer and line capacities to pull them through the soul-trying periods of starting. All this means material increases of plant and equally material decreases of load factor, hence it is no marvel that direct-current traction, which possesses none of these disadvantages, has won the favor of preference among engineers.

⁂

Nevertheless, time is disproving the belief formerly held that induction motors are inherently so constituted that they are adapted for service only under conditions of continuous duty at approximately full load, for now they are being used with complete success as crane motors in mills and factories, and Prof. D. C. Jackson, in the recently-issued and incomparably superb "Street Railway Number" of *Cassier's Magazine*, refers to their successful use in elevator service in various buildings from four to six stories high; and, more than this, readers of the JOURNAL are familiar with the hoist at the War Eagle mine in Rossland, B. C., which is operated by a three hundred-horsepower induction motor with rheostatic control. A three-phase railway plant installed by Messrs. Brown, Boveri & Co., of Baden, Switzerland, has been in operation in Lugano, Switzerland, since June, 1896, and another polyphase line in successful operation at Evian-les-Bains, France, was installed by Messrs. Ganz & Co., of Buda-Pesth. The mountain railway which climbs the Gorner Grat is equipped with polyphase motors, as are also several other railway lines in Switzerland, notably that for the Jungfrau. Still another polyphase railway is being installed at Varese, Italy, and it is gratifying to know that the installation is being made by an American concern—the General Electric Company of New York.

⁂

Prof. Jackson, in discussing polyphase electric railways in the magazine just referred to, states that there are now no less than three methods of greater or less advantage, depending upon local circumstances, by means of which polyphase alternating currents may be utilized in transmitting or distributing power for electric railways. These involve:

First. Rotary transformers in auxiliary stations driven from polyphase alternators in a centrally located principal station, a continuous-current distribution for the heaviest district immediately around the principal station being also maintained from it.

Second. Polyphase alternators driven by water or steam power at an economically located principal generating station, with rotary transformers along the line to feed standard continuous-current motors.

Third. The same arrangement of generating station as in the second method, which feeds polyphase motors on the cars.

The first method finds a notable illustration in the street railway installation now being made in New York City, and the second method is followed out in a number of electric railways of the East on inter-urban lines. Of the third method America has no exemplification, but Europe has, as appears in a preceding paragraph.

⁂

Europe also has another distinctly remarkable, although experimental, railway departure, namely: the Heilmann locomotive, which is a complete steam-electric generating station on wheels, making electric power only for the purpose of supplying its own motors. Although this electric locomotive was built in 1895, no data concerning its performance has yet been available; but its builders calculated that a locomotive of this type costing £6000, and having an output of 1500 horsepower, would be capable of hauling a fifty per cent. greater trailing load at fifty per cent. higher speed than a steam locomotive of equal weight and engine capacity, and that this result would be obtained through the use of a large and economical boiler; on account of few working parts and consequent small friction losses; by the application of a system of motor control which varied the current in proportion to the draw-bar pull and the voltage in proportion to the speed; that it would avoid losses in dead resistance, and that the engine (driving the generator) would run at full speed irrespective of grades, speed or output. In this last feature it possesses, of course, a very great advantage over the standard steam locomotive.

⁂

The utilization of polyphase currents for electric traction through the use of rotary transformers along the line to feed standard continuous-current railway motors, passed the experimental stage when success attended the efforts which had been made to prevent the "pumping" or "hunting" of rotaries. Now hundreds of miles of suburban electric roads are so operated, but rapid progress in the building of long lines using direct-current system with feeding-in stations containing rotary transformers, will be forestalled so long as copper remains at prohibitive prices—for direct-current motors require copper (or aluminum), and tons and tons of it in every railway system of considerable magnitude.

All problems find ultimate solution through applications of the inflexible laws of commercial economy, hence to this tribunal must these questions concerning long-distance electric railways inevitably go. The ingenuity of engineers will never be exhausted, and while their preferences for the direct-current system are balked for the time being, their extremities may force them to devote their energies to the development of a system of electric traction wherein the polyphase system with high-voltage trolley wires and feeders will render the cost of line and feeder construction to be of nominal import, whereas it is a vital consideration at present. To do this may require the building of electric locomotives which will carry station transformers and rotary converters for furnishing direct current for the operation of ordinary forms of continuous-current electric locomotives somewhat after the manner of the Heilmann locomotive, but if so, so be it. Why not?

MESSRS. KEELEY, HOWARD & CO., FRAUDS.

For many weeks past the daily papers of San Francisco have had no dearth of sensational matter to cater to their readers; for the robbery of five thousand sovereigns from the treasure room of the trans-pacific liner "Alameda," the gold-bestrewn career of "Plunger Hill" at the races, the deceiving of well-known engineers and the fleecing of shrewd capitalists by so-called revolutionizing gas processes, the Green-Howard controversy, and the alleged "shaking down" of Howard by the San Francisco police for $52,000—with all of which the name of Howard has been coupled—have proven an inexhaustible source of sensationalism to the keen delight of at least the papers themselves. The engineering fraternity have also found the case to be not without interest, for if a tithe of that with which Howard has been charged is true, the world has cause to regret the alleged perversion of his engineering talents from the paths of legitimate operations.

However much his gas scheme has been talked about, it is true that until very recently no one has yet been able to discuss it understandingly. A veil of mystery has heretofore encompassed the production of "the Howard material" and "the Howard gas," but now it appears from a communication from Mr. Frank H. Bates, appearing on page 71 of this issue, that Mr. Bates has had facilities extended to him for making the closest possible investigations of both the Howard material and gas, and that his investigations have warranted him in denouncing the Howard gas process as fraudulent. Mr. Bates is by no means unknown to readers of the JOURNAL through the publication of the serial on "Industrial Gas" now running in its columns, and as his opinions are authoritative, the death knell of the "Howard gas" has been sounded in this locality. Howard is now a fugitive from justice, but his possible arrest and trial precludes, for the present, the publication of an article which has been prepared by Mr. Bates delineating the technical side of the gas process that afforded the criminal means by which Howard was enabled to wring hundreds of thousands of dollars from the hands of tight-fisted capitalists.

Mr. Bates' article will appear in these columns in due season however, and then will be known for the first time the most interesting features of gas engineering involved in the production and perpetration of the now notorious Howard gas swindle. As it is, the shade of Keeley has found a new partner in crime, and history will long tell of the romantic though inglorious career of the allied partnership of Messrs. Keeley, Howard & Co., the princes of nineteenth-century frauds.

TRANSMISSION AS VIEWED BY A COAL MERCHANT.

Those who have predicted that the bulk of power consumed within a radius of 100 or 200 miles of water power would be of the electrically-transmitted variety, have a new and valuable opinion to substantiate their views: that of John L. Howard, the well-known coal merchant, and perhaps highest authority on fuels on the Pacific Coast. In a paper on "The Fuel Question in California," read before the recent seventh annual meeting of the Pacific Coast Gas Association, Mr. Howard said:

> At the present rate of progress, every stream running down the Sierras, and throughout the length of the State will soon be turning water wheels to furnish electric power at points more or less distant. Of course, one hears discussions upon the limitations of transmission distance; but, taking the art ten years since and comparing it with the present as to the per cent. efficiency of water wheels and generators, of the losses in the processes and in the transmission and delivery, it is a far cry from one condition to the other. Have the electricians reached the *ultima thule?* Is 100 miles, or any other distance, the profitable limit for transmitting electricity generated from streams? As in the case of oil, coal will be displaced as fuel by electricity in all places where it is proven that the unit of effective work is less costly than with coal.
>
> The coal trade has witnessed the loss to it of many a small customer who, for convenience or for economy, has purchased electric power generated from steam at city power stations. It now knows that aggregations of capital have made large installations in the mountains, are wiring the country byways and have contracted to deliver current in the largest coal markets, presumably at a cost less than the buyers could generate it for by the use of coal. We are promised soon the spectacle of a struggle between two giants in the business of light and power, each working on different lines; but, in the ordinary course of affairs, the outcome will not be upon the basis of the survival of the fittest.
>
> All this handwriting on the wall should be legible to the coal producer. He will ultimately have no alternative but to make such a reduction in the cost of his product as will enable him to retain part of the business, for some of it will surely be lost to the coal trade.

Gas

INDUSTRIAL GAS.—VI.

BY *FRANK H. BATES.*

[THE HEMPLE APPARATUS—CONTINUED.]

WE now have all the data for the computation of the hydrogen, methane, and nitrogen.

Methane in portion of gas residue exploded, 14.5 cubic centimeters equaled 5.9 cubic centimeters. By proportion, the methane in the total gas residue, 87.1 cubic centimeters, would equal, therefore:

$$87.1 : 14.5 :: X : 5.9;$$

$$\text{or, } X = 35.4; \quad \text{or, } CH_4 = 35.4 \text{ per cent.}$$

Hydrogen in portion of gas residue exploded, 14.5 cubic centimeters, equaled 8.09 cubic centimeters, since

$$H = \frac{2C - 4D}{3}$$

in which H = hydrogen
C = contraction
D = methane
the contraction = 23.95
the methane = 5.9

hence by substituting

$$H = \frac{2(23.95) - 4(5.9)}{3} = 8.09$$

and for the total gas residue the hydrogen is found by proportion

$$87.1 : 14.5 :: Y : 8.09;$$

$$\text{or, } Y = 48.5; \quad \text{or, } H = 48.5 \text{ per cent.}$$

Tabulating the amounts found:

$$\begin{aligned} CO_2 &= 0.4 \\ C_2H_4 &= 4.3 \\ O &= 0.5 \\ CO &= 7.7 \\ H &= 48.5 \\ CH_4 &= \underline{35.4} \\ & \ 96.8 \end{aligned}$$

hence the nitrogen found by difference is

$100 - 96.8 = 3.2$ cubic centimeters; or, $N = 3.2$ per cent.

SPECIAL SCHEMES.

The Fractional Combustion of Hydrogen. By use of the apparatus shown in Figure 20 the amount of hydrogen present in a mixture consisting of hydrogen, nitrogen and methane may be obtained by direct absorption, the methane being subsequently determined by ignition in the explosion pipette, and the nitrogen by difference. In Figure 20, *a* and *b* are the level-tube and measuring burette respectively; the latter being connected by means of the capillary E to a special tube H, of about four millimeters ($^5/_{32}$-inch) internal diameter, and some 20 centimeters (about 8 inches) in length, containing about four grains of palladium sponge. The palladium tube H is connected by another capillary tube, E′, to a simple pipette which may contain water, or, if preferable, potassium hydroxide, by use of the latter avoiding the necessity of an extra pipette. The pipette serves as a receiver. The beaker, in which is placed the tube H, is nearly filled with water, the temperature of which may be maintained at such a degree as to make possible only the absorption of the hydrogen.

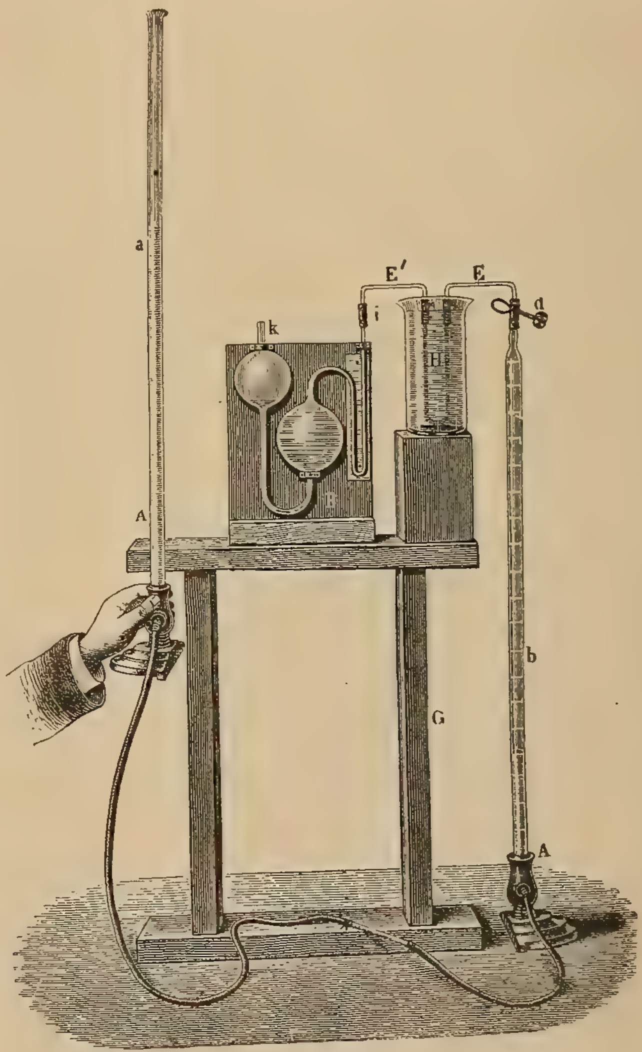


FIGURE 20.

Operation. After completing the removal of all the absorbable constituents of the gas mixture other than hydrogen, and with the gas residue in the *ammoniacal* cuprous chloride pipette, draw into the measuring burette some of the gas residue, and, after waiting three minutes for drainage, measure. Join the burette to the palladium tube and receiving pipette B by means of the capillaries, having previously drawn the liquid in the pipette to the mark on the capillary stem, as heretofore directed in connection with the use of the Hemple pipette. Bring the temperature of the water in the beaker to about 95° C., not allowing it to exceed 100° C., nor fall below 90° C. Open the pinch-cock *d*, and by raising the level-tube *a*, force the gas through the capillary and palladium tubes and into the pipette. Return the gas to the measuring burette and repeat the transfer a couple of times. Replace the hot water by fresh water of about the temperature of the room, and thoroughly cool the gas by leading it back and forth through the palladium tube a few times. By now measuring the gas volume and thus determining the contraction, taking account of the air contained by the capillary and the palladium tubes, the amount of hydrogen in the sample of gas residue becomes known, since in the presence of the palladium, all of the hydrogen unites with such oxygen (afforded by the air added) as is required for chemical union. The product being water, two-thirds of the contraction equals the volume of hydrogen, as is readily seen by the following equation:

$$\underset{\substack{\text{Hydrogen}\\ \text{2 vols.}}}{(H_2)_2} \underset{+}{+} \underset{\substack{\text{Oxygen}\\ \text{1 vol.}}}{(O_2)_1} \underset{=}{=} \underset{\substack{\text{Water}\\ \text{0 vol.}}}{H_2O}$$

Two volumes of hydrogen unite with one volume of oxygen to form water possessing no appreciable volume.

Having determined the hydrogen by the palladium absorption, draw into the measuring burette another portion of the gas residue from the *ammoniacal* cuprous chloride pipette; wait three minutes for drainage and measure the volume. Pass this into the explosion pipette and then add the requisite quantity of air and pure hydrogen; the latter is generated by means of the hydrogen pipette already described.* (See Figure 16 in the August number of the JOURNAL.) The gases are now thoroughly mixed and ignited by means of a spark. The contraction, due to combustion, is measured, and the carbon dioxide formed is absorbed by passing the products of combustion into the potassium hydroxide pipette. The absorption is then measured.

We now have sufficient data for the computation of the constituents of the gas residue.

The total contraction produced corresponds to:

1. The hydrogen present in the original gas (this is ascertained by the palladium absorption) plus one-half its volume of oxygen, the quantity requisite for complete combustion.

2. The measured quantity of hydrogen added, plus one-half its volume of oxygen.

3. The methane present (equal to the carbon dioxide formed, as measured by the potassium hydroxide absorption) plus two volumes of oxygen requisite for its combustion.

Knowing the percentages of both the hydrogen and the methane, we need only be concerned as regards the nitrogen. Its volume or percentage is readily found by adding the percentages of all the other constituents and subtracting the total from 100, the result being the percentage of nitrogen.

It is not absolutely necessary to measure the carbon dioxide formed to determine the methane; simply ignite the mixture of gases in the explosion burette, and then, without measuring the contraction, transfer to the potassium hydroxide pipette for the absorption of the carbon dioxide formed; after which, measure the volume to ascertain the total contraction, which will equal the sum of the contractions 1, 2 and 3.

Since the contractions 1 and 2 are known by taking their sum from the total contraction (the sum of 1, 2 and 3), the contraction due to the combustion of the methane becomes known, and thus the volume and percentage of methane, it being one-third of contraction 3. Thus:

$$\text{Total contraction} = C = 1 + 2 + 3$$
$$\text{then } C - (1 + 2) = 3$$

Now methane—CH_4—in burning unites with two volumes of oxygen; thus:

$$\underset{\substack{\text{Methane}\\ \text{1 vol.}}}{CH_4} \underset{+}{+} \underset{\substack{\text{Oxygen}\\ \text{2 vols.}}}{(O2)_2} \underset{=}{=} \underset{\substack{\text{Carb. Diox.}\\ \text{1 vol.}}}{CO_2} \underset{+}{+} \underset{\text{Water.}}{(H_2O)_2}$$

and the carbon dioxide being absorbed previous to measuring the contraction, gives a contraction due to methane of three volumes for each volume burned, hence one-third of the contraction (3) equals the volume of methane.

It is not even necessary to trouble to make the absorption of the carbon dioxide formed with potassium hydroxide, since in this case the volume of carbon dioxide formed by the combustion, remaining unabsorbed, lessens the contraction by one volume for every volume of methane burned; hence the volume of methane will in this case become one-half of the contraction due to the combustion of the methane.

Conditions to be observed in connection with the absorption of hydrogen by means of palladium:

In a gas mixture, the carbon dioxide, heavy hydrocarbons, oxygen, carbon monoxide, etc., must first be as completely removed as is possible by absorption with reagents. For the absorption of carbon monoxide only *ammoniacal* cuprous chloride may be used, since the acid fumes of the cuprous chloride would tend to unite with the oxygen of the palladium oxide more readily than hydrogen, and in burning not develop sufficient heat to make possible the occlusion of the hydrogen. On the other hand, traces of ammonia do not interfere. Carbon monoxide or large quantities of benzole vapor or vapor of alcohol do interfere, owing, as in the case of hydrochloric acid, to their greater affinity for palladium oxide, and, in consequence, every care should be exercised to remove them as far as possible.

Palladium black is even stronger in its action than oxydized palladium sponge. It is made by reducing palladium chloride with alcohol in a strongly alkaline solution. It is probably a mixture of metallic palladium with palladium oxide.

The palladium may be regenerated by plunging the tube into hot water and passing a current of dry air through it. The palladium should always be kept as dry as possible.

The Absorption of Oxygen by Phosphorus. The employment of moist phosphorus as an absorbent of oxygen is by far preferable to the use of potassium pyrogallate, but this method is not universally applicable. The absorption is carried on in a simple pipette for solids, thin sticks of phosphorus being inserted in the bulbed portion and surrounded by water, which recedes on the gas being forced in, thus affording a fresh, bright surface of phosphorus for each absorption. The moist surface of the phosphorus rapidly absorbs the oxygen, forming phosphoric and phosphorus acid, both of which are dissolved by the water present. The temperature of the pipette should be held at from 18° to 20° C., (64° to 68° F.). About ten minutes should be allowed this absorption.

---

*Oxygen may be used as heretofore should it be preferable.

The following conditions should be observed in connection with the employment of phosphorus:

The oxygen in the gas should not exceed 50 per cent.

The gas should be free from ammonia, ethylene and all hydrocarbons, vapor of alcohol, ether, and etherial oils.

It is owing to the fact that phosphorus is not acted upon by oxygen except the latter is diluted with other gas, that one should not have it present in greater quantity than 50 per cent. In gases rich in oxygen it is easy to dilute with nitrogen to permit of the absorption.

During the reaction, a bright glowing of the phosphorus takes place, and the termination of the oxidation is sharply shown by its disappearance on the exhaustion of the oxygen. The glow is only visible in a dark room. The phosphorus may be repeatedly used but should be protected from the light when not in use. The confining water surrounding the phosphorus should be renewed occasionally to prevent saturation and allow of the products of combustion or oxidation being readily absorbed, and in this way keeping the surface of the phosphorus always bright and active.

Scheme for the Analysis of Coal Gas by which the traces of carbon monoxide remaining from the cuprous chloride absorption, and any ethane present, may be determined.

The writer has found, that even with the exercise of considerable care, there remains some carbon monoxide after the cuprous chloride absorption; and further, that there is generally present in the gas residue traces, at least, of ethane (C_2H_6). He has accordingly arranged the following method for the analysis of a gas mixture, which provides a means for the complete determination of carbon monoxide and ethane. The gas mixture may contain benzene, or benzole vapor, C_6H_6; carbon dioxide, CO_2; heavy hydrocarbons or fixed illuminants, C_2H_4; oxygen, O; carbon monoxide, CO; hydrogen, H; methane, CH_4; ethane, C_2H_6; and nitrogen, N.

ORDER OF ANALYSIS.

1. Benzene or benzole vapors (C_6H_6), absorbed by one cubic centimeter of alcohol in mercury pipette; after measuring the contraction agitate the gas with one cubic centimeter of water to remove alcoholic vapors.

2. Carbon dioxide (CO_2), absorbed by potassium hydroxide. The absorption is nearly instantaneous, one passage of the gas into the pipette generally sufficing.

3. Heavy hydrocarbons or fixed illuminants, consisting principally of ethylene (C_2H_4), absorbed by an aqueous solution of bromine. Fuming sulphuric acid gives a slightly greater absorption, but bromine is far more convenient and sufficiently accurate for most purposes. Time required for this absorption, three minutes.

4. Oxygen (O), absorbed by phosphorus. Time, ten minutes. Potassium pyrogallate may be used, but the first offers a decidedly more elegant method. Time with potassium pyrogallate, three minutes.

5. Carbon monoxide (CO), absorbed by a solution of cuprous chloride. An alkaline or ammoniacal solution of cuprous chloride must be used, since the absorption of hydrogen is to be by means of palladium, which would become inactive in the presence of hydrochloric acid vapors. In making the cuprous chloride absorption, it is advisable to employ two pipettes, one containing a solution which has been used a number of times, and the other comparatively fresh. By passing the gas into the first and agitating therein some two or three minutes, and thus removing the greater part of the carbon monoxide, and then completing the absorption by a passage into the second pipette, retaining there some three minutes. This precaution is taken owing to the fact that the affinity of carbon monoxide for cuprous chloride is but slight, and the resulting union is, in consequence, rather unstable. Even by the use of two pipettes traces of carbon monoxide remain.

The residual gas may now consist of

$$H + CO \left(\begin{smallmatrix}\text{traces remaining unabsorbed} \\ \text{by cuprous chloride solution}\end{smallmatrix}\right) + CH_4 + C_2H_6 + N.$$

This residual gas is retained in the cuprous chloride pipette, a portion, say 20 cubic centimeters, being taken for the palladium absorption. In the palladium reaction already described (the 20 cubic centimeters of residual gas is simply passed, together with the air added, over palladium), are removed the hydrogen and remaining traces of carbon monoxide.

The combustion of the two is represented by the equations:

$$H_2 + (O_2)_{\frac{1}{2}} = H_2O \qquad (1)$$

$$CO + (O_2)_{\frac{1}{2}} = CO_2 \qquad (2)$$

In equation 1, one volume of hydrogen uniting with one-half volume of oxygen, condenses to water. The contraction is therefore one and one-half volumes, which is one and one-half times the hydrogen burned, or $1\frac{1}{2}$ H.

In equation 2, one volume of carbon monoxide uniting with one-half volume of oxygen, contracts to one volume of carbon dioxide. The contraction is therefore one-half the carbon monoxide burned, or $\frac{1}{2}$ CO. In this combustion there is formed one volume of carbon dioxide for each volume of carbon monoxide burned, or $CO = CO_2$. This affords a means of determining the amount of carbon monoxide, since the carbon dioxide may be absorbed by potassium hydroxide.

Collecting, we have for the total contraction due to the palladium combustion:

$C_1 = 1\frac{1}{2} H + \frac{1}{2} CO$, (3) and

$D_1 = CO = CO_2$, (4) in which

C_1 = the contraction due to palladium combustion,

D_1 = carbon dioxide formed by palladium combustion,

substituting in equation 3 the value of CO in equation 4

$$C_1 = 1\frac{1}{2} H + \frac{1}{2} D_1 \qquad (5)$$

and by simple transposition

$$H = \frac{2\,C_1 - D_1}{3} \qquad (6)$$

The operation thus far is then to pass the sample of residual gas, to which has been added air, over palladium, causing the H and CO to be burned. The products of the combustion are then brought back and the volume measured, showing the contraction, which is designated C_1 in the above formulas. The gas is then passed into the potassium hydroxide pipette for the absorption of the carbon dioxide (formed by the combustion of the carbon monoxide). The gas is returned to the measuring burette and the contraction due to the carbon monoxide absorption measured; this equals D_1 in the above formulas. We now know the hydrogen and the carbon monoxide of the residual gas sample.

Another portion of the residual gas is now drawn from the cuprous chloride pipette and measured—say about 15 cubic centimeters—and to this is added about 80 cubic centimeters of air, enough to make a total of nearly 100 cubic centimeters. The mixture is transferred to the explosion burette and well mixed. It is then exploded over mercury. The resulting contraction we will call C—and is due to the following reactions:

The carbon monoxide burning to carbon dioxide

(*a*) $CO + (O_2)_{\frac{1}{2}} = CO_2$ Contraction = $\frac{1}{2}$ CO

The volume of carbon dioxide formed equals the volume of carbon monoxide burned; or, $CO_2 = CO$.

The methane burning to carbon dioxide and water

(*b*) $CH_4 + (O_2)_2 = CO_2 + (H_2O)_2$ Contraction = 2 CH_4

The volume of carbon dioxide formed equals the volume of the methane burned; or, $CO_2 = CH_4$

The ethane burning to carbon dioxide and water

(*c*) $C_2H_6 + (O_2)_{3\frac{1}{2}} = (CO_2)_2 + (H_2O)_3$ Contraction = $2\frac{1}{2}$ C_2H_6

The volume of carbon dioxide formed equals twice the volume of ethane burned; or, $CO_2 = 2C_2H_6$

The hydrogen burning to water

(*d*) $H_2 + (O_2)_{\frac{1}{2}} = H_2O$ Contraction = $1\frac{1}{2}$H

The total contractions (C) resulting from the combustion of residual gas in the explosion pipette is then the sum of the contractions resulting from the reactions expressed by equations *a*, *b*, *c*, and *d*; or,

$$C = \frac{1}{2}CO + 2\,CH_4 + 2\frac{1}{2}C_2H_6 + 1\frac{1}{2}H \qquad (7)$$

The total volume of carbon dioxide (we will designate this D) formed by the combustion of residual gas in the explosion pipette, would equal from the equations *a*, *b*, *c*, *d*

$$D = CO + CH_4 + 2\,C_2H_6 \qquad (8)$$

The procedure is then to ignite the sample of residual gas in the explosion pipette, then returning to the measuring burette to determine the contraction (C), then transferring the gas to the potassium hydroxide pipette to absorb the carbon dioxide formed, afterwards measuring in the burette the volume of absorption (D).

Let us call

$$C - C_1 = E = (\frac{1}{2}CO + 2CH_4 + 2\frac{1}{2}C_2H_6 + 1\frac{1}{2}H) - (1\frac{1}{2}H + \frac{1}{2}CO) = 2CH_4 + 2\frac{1}{2}\,C_2H_6 \qquad (9)$$

Let us call

$$D - D_1 = F = (CO + CH_4 + 2C_2H_6) - (CO) = CH_4 + 2C_2H_6 \qquad (10)$$

Then multiplying F by 2 and subtracting E we have

$$2F - E = (2CH_4 + 4C_2H_6) - (2CH_4 + 2\frac{1}{2}C_2H_6) = 1\frac{1}{2}C_2H_6 \qquad (11)$$

$$\text{or,}\quad C_2H_6 = \frac{4F - 2E}{3} \qquad (12)$$

and further, we have from equation 10

$$CH_4 = F - 2C_2H_6 \qquad (13)$$

The nitrogen is now found by difference making all the constituents of the residual gas known.

One fact to be noticed is that F or $D - D_1$ cannot, under any circumstances, be less than $\frac{1}{2}$E or $\frac{1}{2}(C - C_1)$, since, if in equations

$(F = CH_4 + 2C_2H_6)$ and $(E = 2CH_4 + 2\frac{1}{2}C_2H_6)$

$$CH_4 = 0,\ \text{then}\ F = 2C_2H_6 = \tfrac{4}{5}E; \qquad (14)$$

or, if on the other hand,

$$C_2H_6 = 0,\ \text{then}\ F = CH_4 = \tfrac{1}{2}E \qquad (15)$$

Summing up, the residual gas may consist of

$$H + CO + CH_4 + C_2H_6 + N$$

By the palladium combustion

$$H = \frac{2C_1 - D_1}{3}$$

in which C_1 = the contraction due to the combustion of the hydrogen and carbon monoxide and D_1 = the carbon dioxide resulting = the carbon monoxide burned.

By the explosion over mercury

$$C_2H_6 = \frac{4F - 2E}{3},\ \text{and}$$

$$CH_4 = F - 2C_2H_6$$

in which

$F = D - D_1$ = the difference between the volumes of carbon dioxide formed by the explosion over mercury (D) and the palladium combustion (D_1).

$E = C - C_1$ = the difference between the contraction from the explosion and palladium combustion.

(Continuation in next number.)

Illumination

ELECTRICAL COSTS IN SAN FRANCISCO.

In the report of A. M. Hunt to Hon. James D. Phelan, Mayor, and the Board of Supervisors of the City and County of San Francisco, on the cost of a steam and electric plant for lighting the streets and municipal buildings of San Francisco, and the approximate cost of operating the same, that well-known mechanical and electrical engineer, who is one of the highest authorities on the subject to be found in the west, presents some figures on costs of steam and electrical installation in San Francisco that are well worth reproduction. Prefatory to the report it is stated that in order that a fair comparison may be made between the approximate cost of operation of the proposed plant and the amount which the city is now paying for lighting service, there have been included as requiring service from the proposed plant all the buildings to which light is now furnished, as well as arc lights to cover the present illuminated and settled portions of the city. All buildings under the control of the Fire and Police departments and of the Board of Health, as well as the City Hall and the new Hall of Justice, are to be furnished with light under the estimates given.

Continuing, the report states that it is proposed to locate the plant on property owned by the city on the bay front at the foot of Fillmore street, as at that point water for condensing purposes can be readily obtained and coal can be cheaply landed at the wharf. The installation of three alternators is contemplated, one of 150 kilowatts capacity and two of 75 kilowatts capacity, delivering 2200 volts to line, with secondary distribution at 100 volts. It is proposed, under the report, that the arc lighting plant shall consist of twelve 150 light (2000 candle-power) arc machines belted from six engines, each carrying two dynamos. It is proposed to cover a defined district in the business sections of the city with conduit consisting of two dipped iron pipes, with manholes placed at an average distance of 200 feet. Within this district street lamps will be suspended from ornamental iron poles, placed on the curb line. Without this district wires will be carried and lamps will be placed on 40 foot wooden poles placed 150 feet apart, except along Fillmore street where poles will be placed 125 feet apart. The estimates for wire are based on current (March 20, 1899) quotations for the highest grade of rubber covered copper wire. To cover the resolution of the Board (No. 2266, Fourth Series) calling for additional estimates for supplying commercial arc lights "at actual cost, whenever demanded," an estimate is appended to the report giving the estimated additional cost of plant to furnish 300 arc lamps and the added cost of operation, assuming that they are all in use between sunset and sunrise.

In figuring on the cost of operation of the main plant, it is assumed that incandescent service will be rendered twenty-four hours each day; that street lights will be operated as at present, that is, from half an hour after sunset until half an hour before sunrise on all nights except the night of full moon and the night before and after full moon.

Below are reprinted the various estimates of cost presented with the report:

ESTIMATE OF COST OF STEAM AND ELECTRIC PLANT AND DISTRIBUTING SYSTEM.

1.	Steam plant consisting of boilers to evaporate 40,000 pounds of water per hour, seven engines of 250 horse-power each, two engines of 125 horse-power each, surface condensers, feed pumps and feed water heaters	$ 73,030 00
2.	Piping, valves, etc	7,500 00
3.	Erection of engines, boilers, condensers and heaters	14,629 00
4.	Induced draft blowers, connections and short stacks	5,000 00
5.	Twelve 150-light arc machines erected	32,400 00
6.	Arc light switchboard	300 00
7.	One 150-kilowatt alternator, two 57-kilowatt alternators, erected	5,740 00
8.	Alternating current switchboard	1,950 00
9.	1500 arc lamps, complete	30,000 00
10.	121 ornamental iron poles, in place	7,260 00
11.	5774 wooden poles 7x7 tops, 12x12 butts, 40 feet long, in place	63,514 00
12.	5881 six-pin cross arms	1,470 00
13.	13,000 insulators and pins	520 00
14.	93,333 feet double two-inch iron pipe conduit, laid at 42 cents per foot	39,199 86
15.	450 manholes, complete	22,500 00
16.	49,980 feet No. 00 rubber covered cable	9,996 00
17.	30,660 feet No. 1 rubber covered wire	4,139 10
18.	71,980 feet No. 4 rubber covered wire	6,838 10
19.	124,100 feet No. 6 rubber covered wire	10,548 50
20.	1,120,809 feet No. 6 rubber covered wire (special)	95,268 76
21.	96,333 feet rubber covered, lead and jute armored No. 6 wire (special)	8,188 30
22.	Converters, 43 1-kilowatt, five 2-kilowatt, one 3-kilowatt, one 10-kilowatt, seven 25-kilowatt	3,042 00
23.	Stringing wire	3,972 00
24.	Power station	12,000 00
25.	Real estate	
	Total, excluding real estate	$459,005 43

ANNUAL COST OF OPERATION.

Bond interest 3½ per cent. on $459,005 43	$ 16,065 19
Coal, 8341¼ tons at $7 25 in bunkers	60,473 75
Depreciation (10 years life) 9.1 per cent. on items 9, 11, 12, 13 and 23	9,052 32
Depreciation (13 years life) 6.4 per cent. on items 1, 2, 3 and 4	6,410 18
Depreciation (15 years life) 5¼ per cent. on items 5, 6, 7, 8 and 22	2,258 46
Depreciation (20 years life) 3½ per cent. on items 10, 14, 15, 16, 17, 18, 19, 20 and 21	7,137 85
Six firemen at $75 per month	5,200 00
Three engineers at $100 per month	3,600 00
Three oilers at $75 per month	2,700 00
Five dynamo tenders at $90 per month	5,400 00
One boiler cleaner at $75 per month	900 00
Two horses and wagons at $40 per month each	960 00
Twenty trimmers at $75 per month	18,000 00
Two linemen at $90 per month	2,160 00
Store keeper and time clerk	1,200 00
3000 carbons per diem, 325 days, at $9 00 per 1000	8,775 00
Waste	200 00
Oil	2,555 00
Globe renewals and repairs	1,500 00
Stores and supplies	1,200 00
Chief engineer and superintendent	3,000 00
Insurance, ¾ per cent. on $150,000	1,125 00
Water, assuming waste per diem to equal ¼ of feed	975 84
General repairs (approximated at 2½ per cent. on entire plant)	9,989 70
Total	$170,838 29

The rate of wages on which this table is based, corresponds to those paid by the city in similar cases, but if the rates be taken at those paid by private parties, the estimate may be reduced $8560.

ESTIMATE OF COST FOR 300 ADDITIONAL ARC LIGHTS.

1.	Steam plant increase	$ 10,000 00
2.	Piping, valves, etc.	500 00
3.	Erection engines, boilers, condensers, etc	2,100 00
4.	Two 150-light arc machines	5,400 00
5.	300 arc lamps, complete	6,000 00
6.	210,000 feet No. 6 rubber covered wire (based on average length of circuits)	17,850 00
7.	960 poles set	10,560 00
8.	Cross arms and insulators	280 00
9.	Stringing wires	600 00
	Total	$ 53,290 00

COST OF OPERATION FOR 300 ARC LIGHTS.

Bond interest, 3½ per cent. on $53,290	$ 1,865 15
Coal, 1551¼ tons at $7 25 in bunkers	11,246 25
Depreciation (10 years life) 9.1 per cent. on items 5, 7, 8 and 9	1,587 04
Depreciation (13 years life) 6.4 per cent. on items 1, 2 and 3	806 40
Depreciation (15 yers life) 5¼ per cent. on item 4	283 50
Depreciation (20 years life) 3½ per cent. on item 6	624 75
Four trimmers at $75 per month	3,600 00
600 carbons per diem, 365 days, at $9 00 per 1000	1,971 00
Additional station help	1,440 00
Additional supplies, etc	350 00
Insurance ¾ per cent. on $18,000	135 00
Water	249 84
Proportion of general charges and other items not specified above	2,425 00
General repairs (approximated 2½ per cent. on entire plant)	1,106 50
Total	$ 27,790 43

If wages are taken at rates paid by private parties the above cost will be reduced by about $1200.

Distribution

TESTING LIVE CIRCUITS.

ABSOLUTE continuity of service at any price short of inevitable ruination has become the watchword of many light and power plants, and any expedient that can be adopted to avert the misfortune of necessitating the operation of machinery under conditions imperiling its welfare, is worthy of the earnest consideration of every engineer. An admirable paper presented before the New York convention of the National Electric Light Association by E. A. Leslie, suggests means for testing live circuits which, if faithfully carried out, will do much toward detecting and enabling the removal of troubles that if unattended would develop into serious difficulties. The conditions discussed are particularly those of the underground circuits of New York City, yet the principles involved are of general application, and the instruction given may be followed wherever it is desired to determine the insulation resistance of, or to locate faults on, live circuits. A convenient method for using the telephone in underground testing is also given.

TESTING INSULATION RESISTANCE ON LIVE CIRCUITS.

Sometimes in running a large number of circuits from a common 'bus, phenomena will arise that have a suspicious look and make it desirable to find out which particular circuit or circuits has caused the disturbance. It would have been disastrous to the money-making end of the business if every time something unusual manifested itself we had made a practice of pulling circuit after circuit until the delinquent had been detected, and it therefore became desirable to be able to make reliable insulation tests while the circuits were in actual operation. In order to accomplish this an arrangement of apparatus was devised, such as is shown in Figure 1, and which is described as follows:

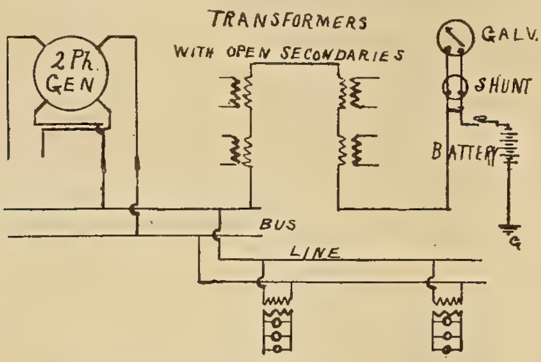


FIGURE 1.—MEASURING THE INSULATION RESISTANCE OF LIVE WIRES.

A spare generator is started and connected through its switches to the test 'bus. From this 'bus a line is carried through a high tension switch and then through the primary coils of four transformers in series, the secondaries being left open, as shown in the diagram. This line is then carried through the galvanometer, which is provided with the usual short-circuiting key and shunt; thence it goes to a battery of 100 chloride cells equipped with reversing key, and from thence to earth. The transformers used are of the ordinary 2000-volt type (which is the pressure used on the New York system), and are of about two-kilowatt capacity each, which we have found by experience to be about the right size. The coils being in series, they offer very high inductive resistance to the passage of alternating current, but their resistance is practically nothing when measuring megohms with direct current.

In making the test, we first ascertain the insulation resistance of the generator, test 'bus, leads, etc. The circuit is then thrown on the test 'bus and tested in the same manner as if it were not connected to a high-tension generator, with the exception that it s not necessary to allow any time for charging or discharging the cable. This is called a "hot" test. The results are the same on testing either leg of the circuit, and the insulation resistance is generally found to be anywhere from 15 per cent. to 75 per cent. lower when tested "hot" than when the circuit is disconnected from the generator and tested in the ordinary way—that is, "cold;" although the lower the insulation of the circuit, the closer the two tests appear to agree. For instance, recent tests on five circuits gave the following:

Circuit No. 24—Hot,	.693 Megohms.	Cold, .83 Megohms.
" " 25— "	.549 "	" 1.84 "
" " 28— "	.975 "	" 1.39 "
" " 29— "	1.95 "	" 2.44 "
" " 16— "	4.75 "	" 10.25 "

When this device was first put into service, and we had convinced ourselves that the readings obtained were really useful, we became impressed with the idea that perhaps we might be able to note the actual effect of the strain of the pressure upon the insulating material surrounding the conductors, and to this end a special set of tests was made, with the following results:

Length of circuit, 4.36 miles.

First test, all converters in (22): Hot, 4.39 megohms total, Cold, 12.94 megohms total.

Second test, all converters out: Hot, 7.56 megohms total. Cold, 28.55 megohms total.

Third test, all converters out except one mounted on glass insulators: Hot, 7.56 megohms total. Cold, 26.4 megohms total.

Fourth test, all converters in after ends had been paraffined: Hot, 4.28 megohms total. Cold, 16.6 megohms total.

While these results are admittedly too indefinite to be regarded as at all conclusive, they nevertheless point to the fact that the insulation of a circuit does depreciate, for the time being, while under the influence of high potentials.

LOCATING FAULTS ON LIVE CIRCUITS.

In locating faults on live circuits a single-pole, double-throw switch *A*, shown in Figure 2, is attached to the test 'bus, and from the center of this switch a lead is carried through the primary of a transformer which has a red lamp connected across its secondary; then through the amperemeter to the diagonally opposite outside poles of a double-throw, double-pole switch *B*; from the other outside poles a wire is carried to the ground. Current is supplied to the center connections of this switch by a small, direct-current, shunt-wound generator having a capacity of about 10 amperes at 250 volts, and by means of this reversing switch the current can be sent through the circuit in either direction. In locating trouble the direct-current generator, which is belted to a five horse-power motor, is started, and the single-throw switch *B* thrown on either side of the 'bus. If the red lamp lights up, it indicates that the ground is on the other leg, and the switch is thrown over. The direct current is then brought up to about seven amperes and the reversing switch *B* is thrown about every 15 seconds, which reverses the direction of the direct current flowing through the cable to the ground. The subway workmen then start out with a compass and go to a manhole through which the circuit in question passes. If, on laying the compass on the cable, the needle reverses every 15 seconds, they know the ground is farther from the station; if, however, the needle is not affected every 15 seconds, it indicates that the trouble is between the manhole opened and the station, and they then open another manhole nearer the station. In this way they are able, without cutting the cables, to locate the trouble in a section between two manholes or handholes, or possibly in a manhole; whereas, prior to the use of this device, we were frequently obliged to cut in 15 or 20 places before locating the fault. In some cases, if the trouble is slight, we are able to repair it without shutting down the circuit, as the men are provided with rubber boots and rubber gloves drawn on over buckskin gloves, and an insulated box to stand upon, and can safely and quickly make a temporary joint that will answer every purpose until such time, say early the next morning, as the circuit can be shut down without detriment to the customers. If, however, the trouble is extensive, the circuit is shut down at once and the repair made as promptly as circumstances permit. Unfortunately, however, the New York subway company objects to the circuit being run, even on an independent generator, while we are locating the trouble, and therefore we now pull the circuit at once and make the test in the same way, except that we use two compasses, as the direct current flows through the primaries of the transformers and tends to mislead the men if they use but one. A compass is placed on each cable, and as long as both needles are similarly affected they know that the trouble is beyond them; when, however, the needles tend to point in opposite directions, they know that they have passed the trouble and its location is then easily determined.

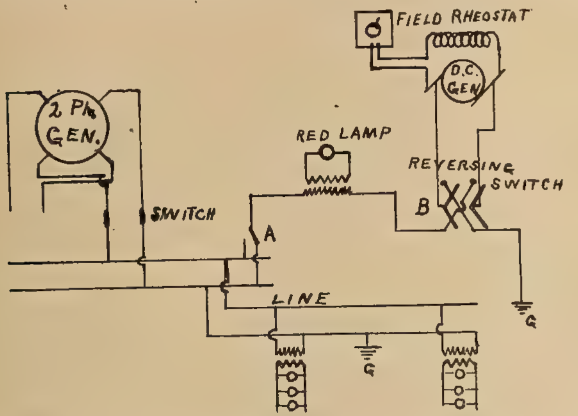


FIGURE 2.—A METHOD OF LOCATING FAULTS ON LIVE CIRCUITS.

It is, perhaps, curious to note that when the alternating current is on the circuit the direct current apparently does not flow through the primaries of the transformers. Trouble on series arc circuits is also located in this way, except that not more than about four amperes of current is used, because otherwise the cut-out magnets tend to act and throw the regular lamp magnets in circuit, the resistance of which practically stops the flow of the current.

TELEPHONE IN UNDERGROUND TESTING.

It has been found by experience that underground circuits, particularly those employed for series arc lighting, need periodical overhauling, otherwise weak spots will accumulate to such an extent as to bring down the total insulation resistance below the standard requirements. At such times a great many galvanometer tests are necessary, and it was found that the work could be done much more quickly if the galvanometer were set up in the station instead of being moved from place to place along the street. The great objection to this, however, was the necessity for frequent communication between the foreman of the subway gang and the tester in charge of the galvanometer, obliging the former to use public telephones a great many times during the day, which was decidedly inconvenient and involved much loss of valuable time. To overcome this serious objection a special telephone set for use on underground cables has been devised by Messrs. Sparrow and Jenkins, and it works very satisfactorily.

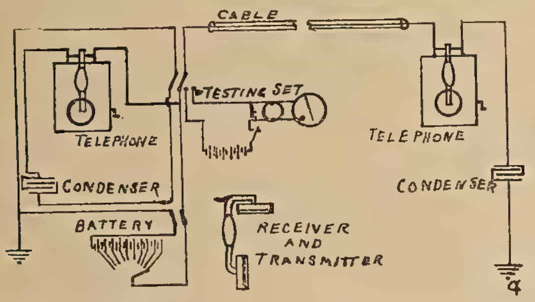


FIGURE 3.—THE TELEPHONE ON UNDERGROUND ELECTRIC LIGHT CABLES.

The magnetos, instead of being wound, as ordinarily, for 10,000 ohms, are wound to ring through 50,000 ohms, and a battery is placed inside of the magneto box, the transformer and receiver being mounted on a separate L-shaped piece connected by a flexible cord to the magneto box. The impedance of the series arc circuits, when used for telephoning, is very great, owing to the capacity of the rubber-covered, lead-sheathed cable, and, in order to talk successfully, it was found necessary to use condensers in connection with both telephones. With their use we are able to hold conversation over our longest series arc circuit, which is 12 miles under ground and three miles overhead, and contains 65 lamps. The method is very simple, as may be seen from the Figure 3. The telephone at the station end, except at time of test, is left constantly in circuit. When the subway foreman has completed his arrangements he connects his telephone, one wire to the copper of the cable and the other to the lead sheath, calls up the tester and so advises him. The foreman then disconnects his 'phone, and the tester does likewise, at the same time switching in his galvanometer. The latter then makes his test and throws his telephone back into circuit. After the lapse of three minutes the foreman also reconnects his telephone and calls up to know the result of the test and get further instructions. In this way the work of overhauling and renovating is very much facilitated, and the cost of maintenance and repair sensibly reduced.

AN INDUCTION FACTOR METER.

BY ALLEN H. BABCOCK.

I TAKE pleasure in complying with the request of the editor to give an account of a device which has been of some assistance to me, although I do not share his opinion as to its universal practical value. It is so simple that I feel certain someone else would have developed it long ago had there been any great necessity for it. I can find no record of such an instrument having been used, at least in the limited library to which I have access here.

During the test of our Thomson recording wattmeters in the Stockton sub-station of the Standard Electric Company of California, we were not a little puzzled when one meter refused to move, although the lamps were up to usual brightness and all circuits were closed. One of the station men finally discovered that the lamps were in one phase, while the potential coil was across the other phase. Here was an obvious explanation of the difficulty, and the remedy was applied.

Some weeks later it occurred to me that if the current of the phase in which the fields of the meter were connected had been either leading or lagging, we would have had a reading of the meter under test, and, in all probability, would have adjusted the meter for the apparent watts indicated. Such a result was an impossibility in this case, since only the lamps for the test were in circuit. However, it suggested a possible source of error in future tests, under different conditions.

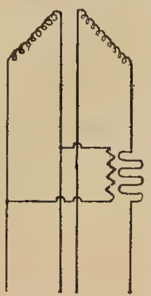


FIGURE 1.

A diagram was made to show exactly what the meter would do with these connections, and it was at once evident that its readings would be proportional to sin φ instead of cos φ, as is the case with wattmeters as ordinarily used; in other words, it would record the wattless component instead of the active. The conclusion was plain that if a recording wattmeter would sum up the wattless component, an indicating wattmeter would indicate it.

A spare indicating wattmeter on the board was connected as shown in Figure 1. The load on the circuit was a 100-kilowatt synchronous motor and a number of lighting transformers scattered about town. The meter showed a slight positive reading, and a little experimenting with the motor exciter demonstrated that it was now possible to tell whether the motor was under or over excited; that is, whether its armature current was lagging or leading. For reasons which need not be discussed here, this was a result of some importance to us.

When the motor is not running the meter shows a lag, as might be expected, since only under-loaded transformers are in circuit.

The sum of our experience is that a wattmeter in a two-phase circuit, connected as indicated above, gives a practical means of telling whether the apparent watts are equal to the true watts, and whether there is a lead or a lag in case they are not equal. It gives also a measure of the wattless component. As connected here, it reads positive for a leading current and negative for a lagging current. The reason for this is shown by the curves in Figure 2, in which the *C* curve is the current in phase *A*, the *E* curve the pressure in phase *B*, and the *W* curve is the product of the two. In the set marked I, the current is in phase with its own pressure, but lags 90 degrees behind the pressure of the other phase, to which the potential coil of the instrument is connected, the sum of the power loops is zero, and the reading is zero. In the set marked II, the current leads its own pressure but lags behind the pressure of the other phase, the sum of the power loops is positive, and the instrument reads positive. In the set marked III, the current lags behind its own pressure, the sum of the power loops is negative, and the reading is negative.

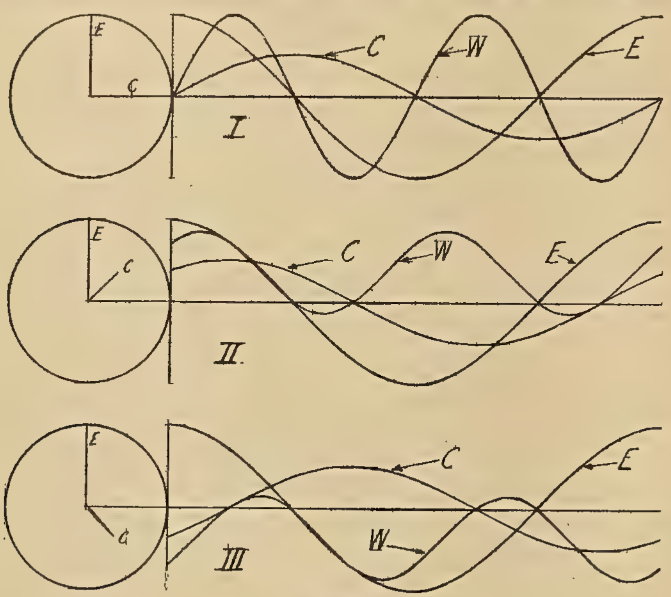


FIGURE 2.

To adapt the instrument to a three-phase circuit it is necessary to get a pressure 90 degrees away from that of the leg into which the current coil is connected, by means of some form of phase transformation.

As stated previously, there is some doubt in my mind as to the great necessity for measures of the induction factor except in certain special instances, of which our case is one. It will be of value in connection with synchronous motors which operate under widely fluctuating loads, or with rotary converters under similar conditions, since it tells at a glance exactly how the excitation should be varied, if at all, which way to vary it, and how much. It will be of service in stations where there is a mixed load of induction and synchronous motors and lights, since it will tell how to vary the excitation of the synchronous motors to bring the power factor of the circuit to a maximum value.

Stockton, Cal., July 22, 1899.

THE GREEN-HOWARD GAS CONTROVERSY.

(Continued from page 71.)

shale was presented as a necessary condition in the manufacture of the solid material, the sale of the Australian shale beds was effected. Mr. Green, deeming this a side issue, did not give this matter very close attention, feeling amply secure in the possession of the acetylene process.

Separating from Howard for the time being, he endeavored to duplicate the results of their joint work, using similar means, and proportioning the ingredients in accordance with the formula furnished, but could secure no results. After fruitless trials, his suspicions being thoroughly aroused, he decided to investigate the shale lands and the several other interests purchased incidentally with the gas process. The results of his investigations have been recounted by the newspapers; how the shale lands had never existed, and of the attempts on the part of Howard to prevent the impending trouble.

It was on the return of Mr. Green from Australia, that, with the conviction of having suffered a swindle, he applied to the Chief of Police of San Francisco for advice. Remarkable as it may seem, the Chief was at this time rapidly completing a line of evidence against Howard in connection with a certain occurrence, and in pursuance of this work had become fully acquainted with his record. He did not hesitate, consequently, to advise Mr. Green of Howard's true character, at the same time stating that on his part he would deem it best to engage the services of one thoroughly posted on the manufacture of acetylene and who might be able to detect the means by which Howard had so successfully carried out his deception. The Chief of Police recommended R. Leo. Van der Naillen, whom he knew to have been associated with the manufacture of calcium carbide in Chicago, and who had some two years previous reported adversely on Mr. Howard's process. Mr. Van der Naillen however, referred Mr. Green to the writer, promising to work in conjunction with him and to render all assistance possible. Acting on this advice, Mr. Green engaged the writer, authorizing him to make a thorough examination of the process in his behalf.

Mr. Howard, being unacquainted with the results of Mr. Green's investigations, agreed to lend every effort to enable anyone whom Mr. Green might introduce as his representative, to look into the merits and the details of his process. After some thirty days association with Mr. Howard, the writer succeeded in securing ample evidence of the fraudulent nature of the work.

Mr. Green was then wired to come to San Francisco—having returned to Denver—to allay any suspicions that might otherwise arise. On making examination of the evidence, Mr. Green, through his legal advisors, began proceedings with the sensational results already known.

Owing to the rather unsettled condition of the case, the writer is not privileged at the present time to make known the technical details, although a review of the evidence secured, involving, as it does, some rather peculiar features from the standpoint of a gas chemist, could hardly fail to prove of interest.

San Francisco, September 10, 1899. FRANK H. BATES.

INSULATORS ON THE SNOQUALMIE LINE.

To the Editor of the JOURNAL,

Dear Sir: We beg to call your attention to an incorrect statement in the leading editorial in your May issue. In describing the power transmission plant of the Snoqualmie Falls Power Company, you stated that the transmission line is supported on Locke glass insulators. If you will look into the matter you will find that the only insulators used on this line are the Imperial high-potential insulators of the Redlands type, the same as are on the lines of the Southern California Power Company, and many others. These insulators were furnished by us and we would be obliged if you would correct your statement in your next issue. C. S. KNOWLES.

7 Arch street, Boston.

Expressions of thanks are due to the writer of the above for calling attention to the misstatement referred to, and in gladly giving the widest publicity to the correction, apologies must be extended to the Imperial people for the injustice which has, through inadvertance, been done them. Sincerity of purpose in the expression of fact or of opinion is the aim of the JOURNAL above all other desires, and its columns are always open for the publication of such criticisms or corrections as are worthy.—ED.

It is advisable that transformers for use on two-phase circuits should each be provided with a lead tapped in to the middle point of the secondary so that, when such transformers are used for motors on a two-phase circuit, the middle leads or taps may be closed together. Normal voltage will then be available across the secondary terminals of either transformer while but 70 per cent. of the normal voltage will be available between any terminal to either secondary terminal of the other transformer, and any two of these 70 per cent. terminals which bear the two-phase relation may be used in starting a two-phase motor, but motors so started should be of small capacity in comparison with the transformers because only a portion of the transformer secondaries are in use during starting. Under this condition the motor will start at half full load torque.

Historical

AN EARLY JABLOCHKOFF ALTERNATOR.

BY PROF. ORION BROOKS.

THE present age is a rapid one. Machinery and methods grow old and become "has beens" so speedily that we may be pardoned for at times standing aside and gazing in wonderment at the swiftly moving scene. Especially is this the case with electrical machinery and methods. By way of emphasis, there is presented herewith an illustration of a pair of Gramme machines consisting of a Gramme exciter and a Gramme Jablochkoff alternator, which may justly be designated pioneers, although not yet twenty years old. These machines are now in the possession of the Heald Electrical Engineering School, 24 Post street, San Francisco, having been rescued from threatened oblivion by the writer, who is its manager.

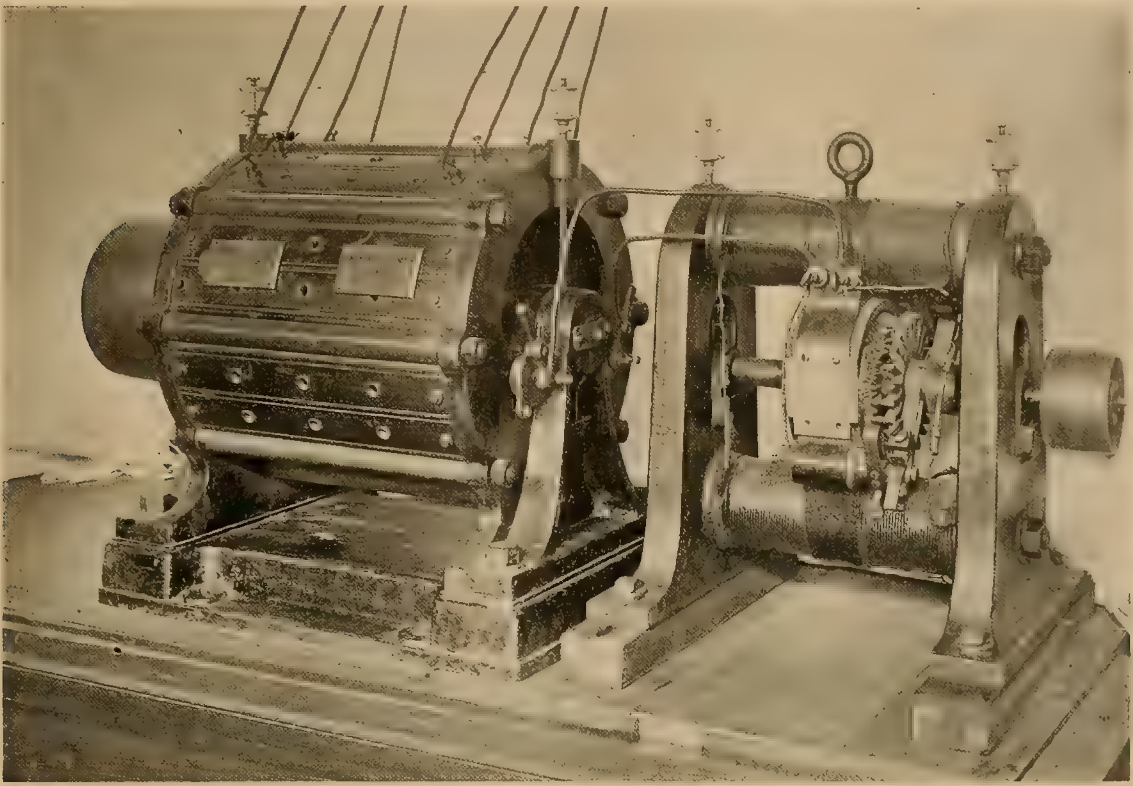


FIGURE 1.—JABLOCHKOFF ALTERNATOR AND GRAMME EXCITER.

These electric lighting machines belong to the experimental era of electric lighting in California, having been imported from Paris in 1879 by the proprietors of the San Francisco *Chronicle*, and were put in service at the time the *Chronicle* was moved from 506 Montgomery street to its then new building on the corner of Bush and Kearny streets, in September of that year, where they were operated until the California Electric Light Company, having become well established, contracted to supply current from its works for less than it was costing at the time they were put out of commission. The exciter scarcely requires description as the illustration is excellent, and is of a more or less familiar type.

A few details concerning the alternator may, however, not be superfluous. It is of the revolving field type with stationary armature, and may be classed as a "double two-phase" machine with capacity of four standard Jablochkoff candles. The field coils, eight in number, marked *F*—Figure 2—are arranged radially inside the armature on a shaft, and are connected two in series and four in parallel to two slip-rings, through which current is received from the exciter by means of copper brushes.

Each field coil consists of five layers of sixteen turns each of No. 10 copper wire, and the resistance from brush to brush is .06 ohm. The weight of the copper on the alternator is: fields, 31 pounds; armature, 36 pounds. The armature is connected up in four sections of four coils each, each section comprising 140 turns of No. 15 wire, the four sections aggregating about 3600 feet, and having a resistance of 12 ohms, or three ohms to each section.

Referring to the plan in Figure 2, the designations *A*, *B*, *C*, *D*, represent the several coils, there being 16 in all. The coils designated *A* are connected in such manner that they all act in conjunction, and the terminals are carried to two binding posts *a a* on top of the casing, and coils *B*, *C* and *D* are connected in like manner. Owing to the mechanical arrangement of the parts, coils *a* and *c* are active at the same instant at which time coils *b*

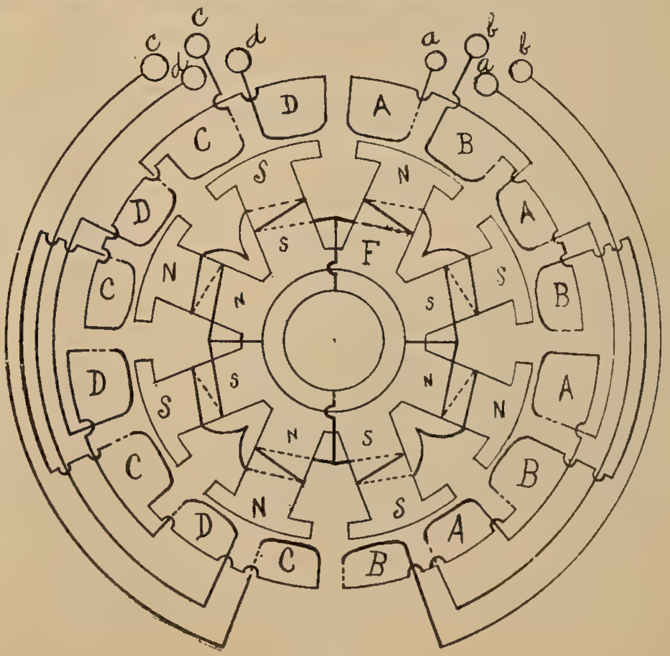


FIGURE 2.

and *d* are at the neutral point, and *vice versa*; hence, sections *a* and *c* may be connected to work either in series for double voltage, or in parallel for double amperage; or they may be worked on independent circuits, and of course the same arrangements may be carried out with *b* and *d*. The capacity of each section is six amperes at 50 volts, or 1200 watts total at 750 revolutions per minute, and energy consumption for driving is about 3000 watts. The commercial efficiency is therefore about 40 per cent.

The students of the college have cleaned up these machines, have fitted new journal boxes thereto, and have put them in working order, and it is interesting to draw comparisons between them and others of modern type alongside of them.

Here the query arises, What will the next twenty years develop? Will our present electrical machinery be relegated to the junk heap from which an occasional piece will be reclaimed and viewed as a curiosity?

The writer, who has been a resident of California for 47 years, hopes, in the near future, to record in these columns some recollections of early electrical projects when electrical engineering had not risen to the dignity of a profession in the Golden West; to write of the time when a certain telegraph superintendent replied, in answer to an inquiry why he did not adopt a system of daily galvanometric tests of the wires under his charge, "If I was to get those d——d ohms on my lines I couldn't work a circuit." His company long since ceased its separate and distinct existence.

Industrial

In responding to advertisements in this publication kindly mention "The Journal of Electricity, Power and Gas."

WAGNER COMPANY'S COAST OFFICE.

The Wagner Electric Manufacturing Company of St. Louis has opened a Pacific Coast office at 120 Sutter street, San Francisco, in charge of Alex. R. Pike, who for the past four years has been in the sales department of the Columbia Incandescent Lamp Company. It is the intention of the Wagner company to hold a large stock of alternating apparatus at this point, and thus be in a better position to handle its Coast business. The California Electrical Works, which has handled the Wagner line in California for the past three years, will still be selling agents for California, Nevada and Arizona, but the branch office will handle their entire business on the Coast.

The company reports a large business on its single-phase motor.

TRADE LITERATURE.*

"Ideal Engines." These high-speed, high-duty engines are described, and their distinctive details and engineering data are admirably shown in a superb catalogue of 54 pages, measuring 6x9 inches. A. L. Ide & Sons, Springfield, Ill.; *Abner Doble Company*, agents, San Francisco.

"Helios Enclosed Arc Lamps." A 12-page flyer, descriptive of the Helios direct-current, constant-potential, 110-volt, enclosed arc lamp. Indoor, outdoor, and ornamental lamps are illustrated and data concerning them are given. Catalogue 26. *California Electrical Works*, San Francisco.

"Transformers." A 6x4½-inch brochure descriptive of the design and characteristics of the Vindex transformers. In addition, specifications, curves, and tables are given on efficiencies, iron loss, regulation, etc. Vindex Electric Company, Chicago, Ill.; *Wybro-Hendy Company*, agents, San Francisco.

"Thomson Recording Wattmeters." There is no trade literature on a higher plane of excellence than that turned out from the General Electric press, and the book now under consideration is a fair specimen of its editorial and typographical productions. After pointing out the requirements essential to a perfect recording wattmeter, the different types of Thomson meters are described in detail with all electrical connections and general information concerning the instruments. Catalogue No. 1016, 8x10½ inches. *General Electric Company*.

"Columbia Lamps." Full size half-tone illustrations of standard and special Columbia incandescent lamps, with specifications of each. Almost every variety of lamp is given. 24 pages, 8x10 inches. *The Columbia Incandescent Lamp Company*, St. Louis, Mo.; branch office, 120 Sutter street, San Francisco.

"Enclosed Arc Lamps." This deals with the different types of enclosed arc lamps for direct and alternating current circuits, indoor and outdoor lamps, and marine, miniature, power circuit, series enclosed, and single and double globe lamps. Each type is well illustrated and its design and advantages are clearly set forth. *General Electric Company*.

"Polyphase Transmission." This is a reprint of a paper read by Charles F. Scott before the National Electric Light Association, March 1, 1894, and revised by the author early during the present year. It is the most concise and clearly presented discussion of alternating current conditions and problems that has yet appeared. Catalogue No. 227, 23 pages; *Westinghouse Electric and Manufacturing Company*.

Westinghouse Catalogues Nos. 110-E, 168-C, 188-B, 200-A, and 229. These are standard bulletins, dealing respectively with "Transformer Fuse Blocks," "Shallenberger Integrating Wattmeters," "No. 38-B Railway Motors," "Generators and Rotary Converters for Electrolytic Work," and "Belt-Driven Railway Generators." As the titles are self-explanatory, and as the quality of these publications is so universally recognized, detailed references seem redundant. *Westinghouse Electric and Manufacturing Company*.

"The Westinghouse Junior Engine," "The Westinghouse Standard Engine," and "The Westinghouse Compound Engine." These are three separate brochures that are exquisite presentations of the distinct features and advantages of the well-known Westinghouse engines. All three catalogues are replete with general information of value to those who operate Westinghouse or other high-duty engines, and the catalogue on the compound engine is especially meritorious in its descriptive features and its data on steam efficiencies. Size, 9x6½ inches, and of 36, 54, and 94 pages respectively. *The Westinghouse Machine Company*, Pittsburg, Pa.

"Architects' and Engineers' Electrical Bulletin." Though this is an advertising publication, yet it is of such exceptional merit as to be well worthy of a place in any technical library. Its articles are by various authors, and while all have a bearing, in at least an indirect way, on the products of the Sprague Electric Company, they are so ably presented that they lose not a whit of their interest by reason of the medium containing them. The publication itself is, typographically, a model of elegance and richness. 50 pages, 9x12 inches. Sprague Electric Company, New York; *The Brooks-Follis Electric Corporation*, agents, San Francisco.

Literature.

MACHINISTS' AND ENGINEERS' POCKET MANUAL; Vest Pocket Edition; size, 2⅞x4½ inches; leather, with rubber band; 381 pages. Published by Laird & Lee, Chicago. Price, $1.00.

This is one of several vest-pocket manuals of technical reference proclivities that have been issued of late, and it is withal, a complete and compact work for its scope. It includes a compilation of rules and solved problems pertaining to steam engines, steam boilers, steam pumps, etc., based on plain arithmetic, and free from algebraic difficulties, together with necessary tables, and data of value in the machine shop, mechanical drawing room, and steam power plant. It embraces a dictionary of terms used in steam engineering and electricity; the construction and operation of dynamos and motors; artificial refrigeration and ice making; treatise on the steam engine indicator, gearing, shafting, lathe screw cutting, etc., etc.

---

*Catalogues mentioned in this department will be mailed gratuitously on application to the concerns publishing them. When writing, mention THE JOURNAL OF ELECTRICITY, POWER AND GAS. Where addresses are not given, they may be found through reference to the Advertisers' Index on page iii.

THE JOURNAL OF
ELECTRICITY, POWER AND GAS.

VOLUME VIII. SAN FRANCISCO, OCTOBER, 1899. NUMBER 4.

*Tangential Water Wheels.**

BY W. A. DOBLE, M. E.

IN support of the contention that the development of tangential water wheels has been purely a matter of evolution from times of antiquity, are cited the works of Branca, 1629, A. D.; Euler, 1754; Borda, 1767; Navier, 1819; White, prior to 1822; Poncelet, 1827; Girard, 1843; Dingler, 1858, and almost innumerable others. Jearum Atkins in 1853 applied for United States letters patent (granted August 10, 1875), for a water wheel which embodied the fundamental principles of the modern tangential wheel; namely, that water be applied to the periphery of the wheel, that the peripheral velocity be one-half the jet velocity, that the direction of flow in the wheel be reversed so that the wheel may absorb the reactive energy of the jet, and that the water leave the wheel without velocity.[1] Independent of Atkins' researches, however, in the early fifties, the miners of California who had water available only in limited quantities but at high heads, developed the "hurdy gurdy" wheel, which was the legitimate forerunner of the modern tangential wheel. It was a crude affair, having an efficiency of about forty per cent. The origin of the name is of interest. If tradition is to be believed, the California miner who came to the Coast in forty-nine or the early fifties, spent his spare time in places of amusement wherein abounded the mirth of liquid cheer and round-about dances. They did not go through the minuet or other demure and stately functions in these dance halls, or "hurdy gurdies" as they were called, and the rickety, boisterous whirl of the dances which they did see—and perhaps (?) participate in—found so striking a counterpart in the whirl of the original jet wheel, that straightway it was dubbed a "hurdy-gurdy" and as such it has been known ever since.

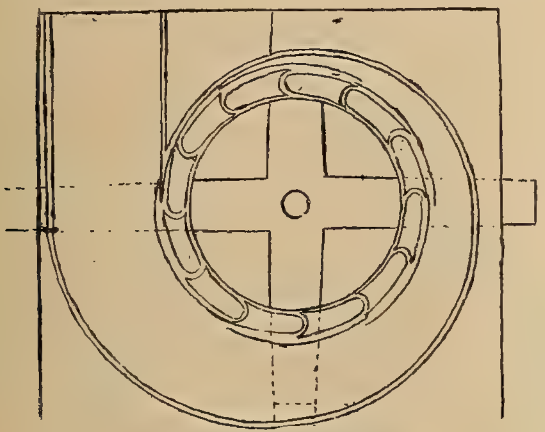


FIGURE 1.—THE ATKINS WHEEL.

The hurdy gurdy wheel was made of blocks of wood about four inches thick, cut out like the teeth of a circular saw, with teeth about eight inches apart. These teeth or buckets were then closed in by casings of wood which formed the sides of the wheel, and from these sides four arms, or spokes, were mortised into a log, the end of which was fitted with a round gudgeon for a bearing. The gudgeon was then placed in a live oak block which had previously been gouged out for the bearing, and this gouging out was generally very roughly done, because of the poor quality of tools which the miner of those days had at his disposal. The water was applied at first in the form of a jet emanating from a hole bored into the end of a wooden block with which the pipe had been plugged. Sometimes the pipe line was of sheet iron and sometimes it was of wood. With heads varying from forty to fifty feet, square wooden pipes were frequently used, these being merely square wooden boxes bolted together with iron rods, if they could be secured, or otherwise the box would be clamped together by means of wood frames, cleats and wedges.

Hurdy gurdy wheels and wood pipe lines of the forms just described were considered good practice in 1854, but as time passed and small quartz mills were erected, it was found that the sphere of usefulness of the hurdy gurdy could be increased to the driving of stamp mills, which it did fairly well when brass nozzles and moderately high heads were used as became the common practice.

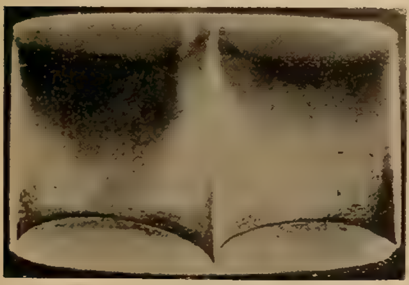
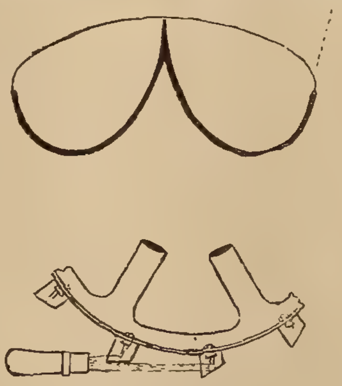


FIGURE 4.


FIGURES 2 AND 3.

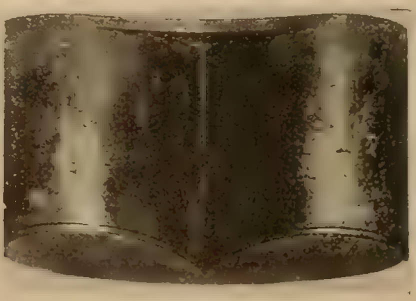


FIGURE 5.

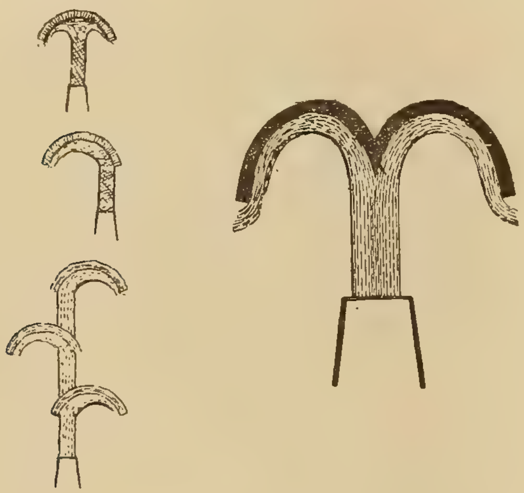
THE MOORE BUCKET.—FIGURES 2 AND 3, ORIGINAL SKETCHES; FIGURE 4, FRONT VIEW; FIGURE 5, REAR VIEW.

---

*Abstract of a paper read before the Thirtieth Annual Convention of the American Institute of Mining Engineers, San Francisco, September 27, 1899.

[1] See *Cassier's Magazine*, Vol. V, pages 109 and 117.

The question of efficiency was never taken into consideration until hurdy gurdy wheels were applied to the operation of large stamp mills, and then it was found that the hurdy gurdy would not develop the power required to give the mill the proper speed, the cause being attributed to the fact that as the buckets were closed in at each side and on the bottom, the waste water could not discharge itself freely, in consequence of which the buckets would remain full during the greater portion of the time during which they remained in the jet. All additional water directed against the bucket after it was filled, merely slipped over the face of the water already in the bucket, and out into the open air.



L. A. PELTON'S FIGURES 6, 7, 8 AND 9.

The hurdy gurdy was a pure impact wheel, and at that time but little if any thought had been given to the reaction of water as applied to the present forms of tangential wheels.[2] About 1866, the Pacific Iron Works of San Francisco installed a wheel in the Gwin mine in Calaveras county which was the first to introduce reaction.

In 1870, S. N. Knight brought out a new type of bucket which was a marked improvement over all previous forms as was demonstrated by its installation in the Gwin mine in 1872 where it operated a twenty-stamp mill. This wheel was of the true tangential type and its buckets were so shaped that they had both side and inward discharges, while most of the latter types of bucket have mainly side discharges. The stream of water applied to the Knight bucket is of rectilinear cross section. But, to revert to the historical side of the matter, the first Knight wheel was made in 1870 and it presented no radical departure from the present form of Knight wheel. In 1872 a Knight wheel was placed in the Gwin mine to operate a twenty-stamp mill, this wheel being first equipped with buckets having an inward discharge; next, they were changed to those having side discharges, and finally the present form was adopted, which has both inward and side discharges.

In 1873 Nicholas J. Coleman secured a patent[3] on a bucket which contained a central dividing wedge for splitting the stream, thus doing away with dead water in the bucket and bringing out the reactive forces of the stream to the best advantage. Coleman was clearly the first to suggest the divided bucket, but its advantages were not appreciated until others had, perhaps independently, perfected it. In 1874, Joseph Moore, of the Risdon Iron Works, San Francisco, submitted a sketch of a divided bucket to G. Tiscornia, of San Andreas, Calaveras county, and buckets made in accordance therewith, as shown in Figures 2 to 5, were shipped to San Andreas on April 13th, 1874. The records of the Risdon Iron Works substantiate Mr. Moore's claim.

L. A. Pelton states that between 1878 and 1880 he tested between thirty and forty different shapes of buckets, and finally noticed that a curved bucket having a jet strike on the side as in Figure 7, instead of in its center (Figure 6), gave marked increase in efficiency, to obviate which he placed the buckets alternately, as in Figure 8, whence it was but a step to combine the two curved buckets into a form which would split the stream as in Figure 9, and thus originated the Pelton bucket.

Prof. F. G. Hesse, of the University of California, was drawn into the controversy by Mr. Pelton in the hope of disproving Mr. Moore's contention, and from his (Hesse's) statement, it appears that between 1865 and 1868 Mr. Moore asked his advice as to the best form of water motor to operate under a high head at a good efficiency, in considering which it occurred to Prof. Hesse that if the separated parts of a form of water wheel then known of, and which is shown in Figure 10, be combined so as to form a single wheel, and one bucket out of every pair of buckets, as in Figure 11, the conditions would be best satisfied. Prof. Hesse states that the drawings for such a bucket were furnished to Mr. Moore presumably between the years mentioned. It seems evident in the light of other facts, however, that Mr. Moore was the first to suggest the generally adopted form of divided bucket, and that the part which Prof. Hesse took is confirmatory of Mr. Moore's contention. In the evolution of the tangential wheel have also figured the names of Biggio[4], Pitchford[5], Donnelly[6], Dodd[7], Watson, Berry[8], Cazin,[9] Tutthill[10], Hug[11], Kale, Ridgway[12], and Bookwalter[13], as well as those of the James Leffell, the Risdon Iron Works[14], and Abner Doble Company[15] with their "cascade," "Risdon" and "ellipsoidal" wheels respectively.

Without entering into a consideration of the features of these types of wheels, it may be said that the ideal bucket would receive the stream in a solid condition and reverse it without breaking; it would discharge the water along natural lines; it would bear such relation to the stream that the plane of the bucket would be perpendicular to its axis and the force exerted by the impact would be equal at whatever angle the plane of the bucket bears to the axis of the jet. The friction between the water and the surface of the bucket should be minimized, ample clearance should be given the buckets to permit free discharge, buckets should be given the longest possible arc of contact with the stream, the face of the buckets should not beat or slap the stream, and buckets should

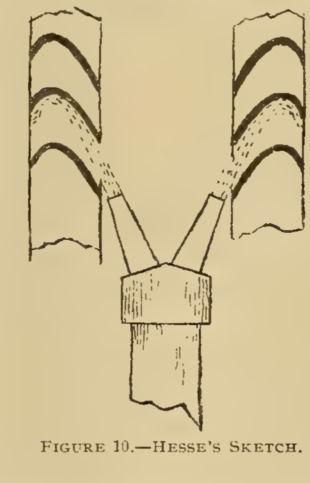


FIGURE 10.—HESSE'S SKETCH.

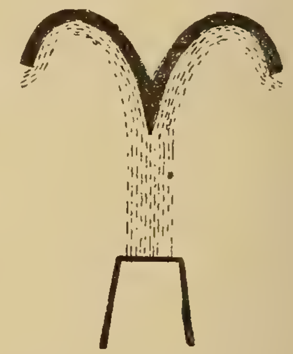


FIGURE 11.—HESSE'S BUCKET.

---

[2] The author gratefully acknowledges his indebtedness to Mr. S. N. Knight, of Sutter Creek, Cal., for most of the information given concerning hurdy gurdy wheels.

[3] U. S. Letters Patent, No. 135,891, February 18, 1873.

[4] U. S. Letters Patent, No. 356,977, February 1, 1887.

[5] U. S. Letters Patent, No. 485,477, November 1, 1892.

[6] U. S. Letters Patent, No. 255,259, March 21, 1882.

[7] U. S. Letters Patent, No. 401,484, April 16, 1889, and 454,638, June 23, 1891.

[8] U. S. Letters Patent, No. 493,239, March 14, 1893.

[9] U. S. Letters Patent, No. 578,812, March 16, 1897.

[10] U. S. Letters Patent, No. 534,772, February 26, 1895.

[11] U. S. Letters Patent, Nos. 576,728 and 576,849, February 9, 1897.

[12] U. S. Letters Patent, No. 453,449, June 2, 1891.

[13] U. S. Letters Patent, No. 469,959, March 1, 1892.

[14] U. S. Letters Patent, No. 599,845, January 26, 1897, and 626,568, March 1, 1898.

[15] U. S. Letters Patent, Nos. 619,148 and 619,149, February 7, 1899, and 613,184 September 19, 1899.

enter and leave the stream with the utmost quickness. Moreover, buckets of the most familiar forms split the stream on entering it in two planes; *viz.:* the entering lip splits in the plane transverse to the wheel's rotation, while the dividing wedge in the center of the bucket splits the stream in the direction of the wheel's rotation. This transverse splitting is both unnecessary and undesirable. A bucket that will not split the stream transversely and which will be of such shape as to preserve this perpendicular, is found in the ellipsoidal type which has no entering lip and the shape of which is described from true hydraulic curves.

Substantiation of this will be found in an examination of buckets taken from wheels that have been run by water containing sand, grit or slickens. Under these conditions, the faces of buckets containing entering lips will be found to be badly worn from striking against the jet. Such a wheel, having forty buckets and run at 1000 revolutions per minute, breaks up the jet at the rate of 40,000 times per minute by blows struck by the face of the bucket, causing the wear against the outer surface of the lip, and, what is far more serious, wasting the energy of the stream. The inner side of such a bucket will be found to be seriously eroded from the swirling action of the water in inner corners because the bucket is so formed as to prevent proper discharge. The reason will be clear from an examination of Figure 12. The jet, striking on the inner side of the face of the bucket, glances off the surface at an equal angle, for the "angle of incidence is equal to the angle of refraction." This glancing action occurs at three points within the buckets; *viz.:* on its front, bottom and rear faces — all of which is clearly shown by lines of erosion that will be found to have been cut by the sediment within the water. The consequence is inevitable that a swirling or whirlpool action will take place at the corners *f*, *g* and *h*, resulting in great loss in energy and the eventual perforation of the bucket at these points. Buckets made on true hydraulic lines show no pitted erosions, and such wear as occurs is in straight lines and even throughout.

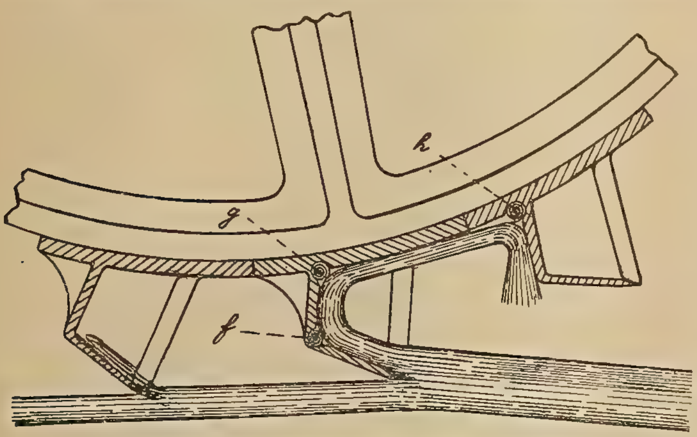
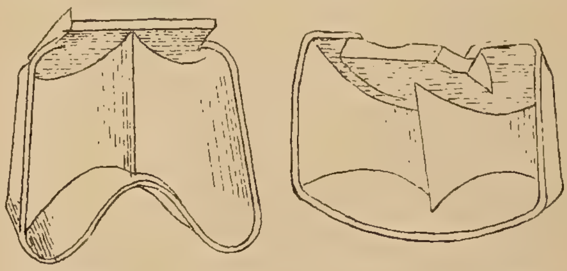


FIGURE 12.—ILLUSTRATING THE EROSIVE PROCESSES.

Buckets of more familiar forms are characterized by the broad edge which forms the entering lip, and the jet-splitting wedge placed radially along the center They, therefore, exert a two-fold influence upon the stream; first, the entrance of the bucket into the jet causes the stream to be split by the entering lip in a plane that is axial to the wheel; second, as the portion of the jet which is diverted into the bucket encounters the splitting wedge therein, the water is again divided whence it endeavors to flow in accordance with natural laws, but instead of doing so it is ordinarily forced to pursue the path provided for it. These lipped buckets are therefore pernicious in several respects, for they not only divert the stream from its natural course while the lip is passing through the stream, but they permit the bucket to be drawn into the jet comparatively slowly, whereas it should be done with the nearest approach to instantaneousness that is possible.

Heretofore, makers of tangential wheels have failed to realize that the action of a jet of water on a stationary bucket is altogether different from that which occurs on a moving bucket; hence most wheels have been designed to give maximum impulse and reaction when the base of the bucket is perpendicular to the axis of the stream. The error is a natural one; for the maximum torque which a tangential wheel which is held stationary will exert will be given when the direction of the jet is as stated: perpendicular to the plane of the bucket, which demonstrates that the angle of maximum effort which a jet can exert is fixed at ninety degrees. There are two ways by which this condition may be satisfied, one of which is thoroughly impracticable, while the second is thoroughly simple and effective. The feathering paddle wheel offers the key to the first solution, for as it always enters the water on the perpendicular, it would sustain the plane of a water wheel bucket at the perpendicular to the axis of the stream during the arc of contact. The execution of this in connection with tangential wheels with their high rotative speeds and centrifugal force, presents mechanical difficulties which preclude all hope of its successful application. The second solution is found deeply veiled in the Berry bucket, the reciprocal of which furnishes the hydraulic curves for the faces of buckets as will give a smooth, even and uniform distribution of forces over practically the entire surface of the bucket regardless of its position in the arc of contact with the stream. Before discussing the ellipsoidal bucket, it will be well to give further consideration to the remaining features of the ideal bucket. The manner in which the jet is brought into contact with the bucket is of paramount importance. All will concede that the stream should enter the bucket in a solid condition, and that, in other words, the stream should be divided or disturbed in the least possible degree. The form of entrance lips are of two classes; namely, straight and in-curved. The great majority of buckets are of the straight-lipped variety, as in the original Pelton, Risdon, Hug, Cazin and other well-known forms. The main examples of the curved-entrance variety of buckets is found in the Dodd wheel and the ellipsoidal bucket, which has no entering lip. I can not but believe that of these two last named buckets the latter is the more efficient for the conclusive reason that the Dodd bucket is so formed that the stream is split before entering the bucket by the in-curved lip, while in the ellipsoidal bucket the solid stream is not split or otherwise interfered with in any manner whatever until after it is within the bucket and reaches the dividing wedge. In fact the only contact on entering the ellipsoidal bucket into the stream is that with the dividing wedge. A straight-lipped bucket breaks up the stream and deflects it during the transit of the lip; it diverts the stream outwardly because of splitting it as by a wedge having an edge which is axial to the wheel, and thus it splits the stream transversely before the wedge in the bucket has had an opportunity to split it radially to the wheel and reverse the direction of the water. In the ellipsoidal bucket the stream is divided only in the plane in the wheel's rotation, thus dividing the stream in only two equal parts, each of



FIGURES 13 AND 14.—THE DODD AND PELTON BUCKETS.

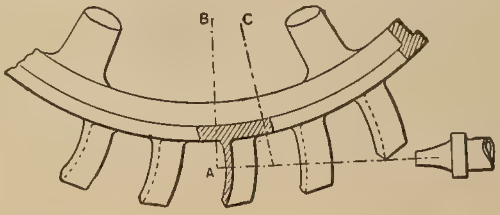
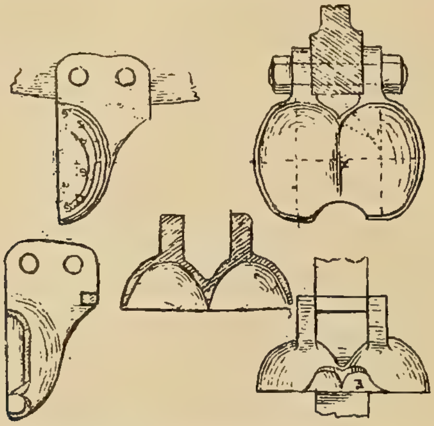


FIGURE 15.—THE BERRY BUCKET.

which flows over the hydraulic-curved faces in the bucket. This reverses the direction of flow of the stream without disturbance or shock and avoids the eddy currents that are set up where an end lip is used. Buckets of the entering-lip type first shave off the stream in thin slices, each slice being again divided by the central dividing wedge, and this additional disturbance to the stream preventing the smooth flow of the water through the bucket which is essential to high efficiency.


FIGURES 16, 17, 18, 19, 20.—SECTIONAL VIEWS OF THE ELLIPSOIDAL BUCKET.

The problem of the resolution of forces of the tangential wheel changes with each and every change in the position of the bucket with reference to the stream. The first thorough appreciation of these variations in forces of which there is authentic record, appears in the Berry patent (1893), Figure 15. The idea which prevailed in the design of the Berry bucket[16] was that the axis of the stream should be tangential to the surface of the bucket at whatever its position within the arc of contact with the stream, to accomplish which, buckets of convex forms, of a carefully calculated curvature were used; but they never saw commercial usage for the reason that the patent went the way of many other inventions and was "shelved" by its owners, perhaps because of the fact that while the axis of the stream, being an imaginary line, may be perpendicular to the tangent of the surface of the Berry bucket, the stream itself, having breadth, and consequently bulk, can never be such.

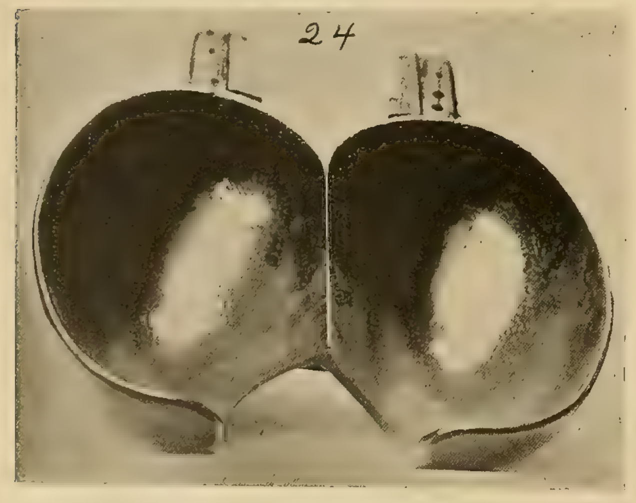


FIGURE 21.—THE ELLIPSOIDAL BUCKET.

In the ellipsoidal bucket, the stream is not split transversely; the first and only splitting of the stream is that caused by the radial dividing wedge within the bucket, and the curvature of the bucket is such that the resolution of the forces exerted by the stream are always in lines tangential to the surface of the dividing wedge whatever be its position in the arc of contact with the jet. Thus is the highest possible efficiency in tangential water wheel practice attained.

The writer is therefore constrained to say that the latest and most important change and improvement in tangential water wheel practice since the development of the Coleman and Moore buckets, has been the recent adoption of what may be called hydraulic curves for the faces of the buckets, and in dividing the jet vertically or radially and in one plane only, *after* its entrance within the bucket.

The first of those features has, by some strange oversight, escaped the attention of engineers. For fifty years past it has been a prominent and even essential feature of turbine practice; and indeed in all of the refined type of water wheels wherein the water was reversed in its course over the faces of the buckets, but has not been considered, or at least has not been applied, in tangential wheel practice until when buckets as shown in the outline drawings, Figures 16 to 20, were adopted for wheels installed for operation in large units under high head. Previously, the faces of the buckets had either been true curves, or developed curves that did not conform to the hydrodynamic conditions demanded. Figure 21 shows an ellipsoidal bucket for a 1000-horsepower wheel, while Figure 22 shows the ellipsoidal bucket as mounted on a finished wheel that is in daily operation under a head of 1300 feet.

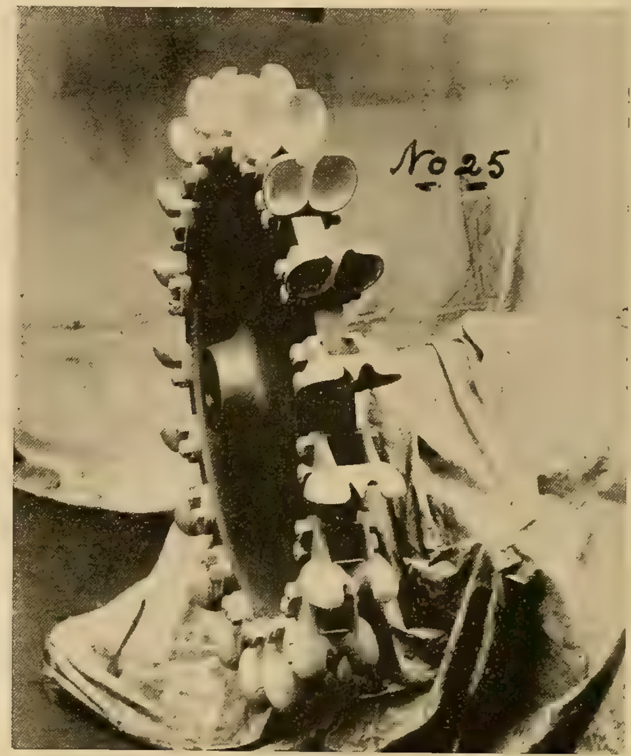


FIGURE 22.—A 1000-HORSEPOWER ELLIPSOIDAL WHEEL.

The extreme simplicity of the tangential wheel, its low first cost, its very high efficiency — over 80 per cent. — gives it a ready adaptability in the engineering field. Wheels have been made in California in diameters varying from three inches to thirty feet, to work under heads of from 35 to 2100 feet, and under speeds ranging from 65 to 1150 revolutions per minute. Its use is not limited altogether to conditions of high head in nature, as it is eminently adapted for certain classes of work such as in rolling mills or in other instances even where high pressure must be given to the water by modern high duty steam pumping engines. Tangential wheels can be installed in units of any desired capacity; their high efficiency is maintained, irrespective of load, by the use of regulating nozzles; they enable the centralization of the steam plant and prevent losses due to long lines of steam piping; they occupy but a fraction of the space taken by steam engines; they are started, stopped, reversed or run at any desired speed with the utmost facility; they stand all sorts of abuse and neglect and require practically no attention; they are unaffected by external surrounding conditions, and under proper installation their efficiency is oftentimes as high and sometimes much higher than other systems of power distribution, while the cost of installation and maintenance is far less.

---

[16] See *Cassier's Magazine*, Vol. V, page 125, *et seq.*

As compared with the turbine, the first cost of the tangential wheel, when considering heads of over fifty feet, is very much less; its cost of maintenance being but a fraction of that of the turbine. In addition to the fact that its initial efficiency is superior to that of the turbine, it also maintains its original high efficiency throughout its life, whereas with the turbine the efficiency is constantly decreasing as the wheel wears in the casing, which allows the water to pass by instead of through the wheel. The variation in design permissible in turbine practice is quite limited as regards speed and power owing to the excessive cost of turbines of large diameter, whereas with the tangential wheel it permits of a very wide and free scope to the designer.

Transmission

ROTARIES IN THE HARTFORD PLANT.*

BY W. L. ROBB.

OF the three 60-cycle alternators in use in the Hartford transmission plant, one is operated by steam and the other two are operated by water power at a distance of eleven miles from the first. These generators have been continuously run in parallel during the last three years and no difficulty whatever has been found in this method of operation.

The operation of the rotary transformers has not been so simple a matter. At the outset there was great excess of sparking at the commutator. This sparking was soon found to depend very largely on the variety of brushes used. It was found that a very soft carbon brush gave the best results, but without special treatment of the brushes, sparking, although diminished, is still excessive. The method of treating the brushes suggested by our superintendent was tried and found effective. The carbon brushes are first raised to a red heat, and then plunged in ordinary lubricating oil and allowed to cool. When brushes treated in this manner were used all vicious sparking was stopped, and in this particular the transformers ran as smoothly as direct-current generators of the best type. At the outset, in operating the rotaries considerable difficulty was met with in preventing pumping at times when the engines were supplying power to the system. This pumping could be traced to the variation in the angular speed of the engines, and when the water power alone was supplying the power there was little, if any, pumping. It was found that this tendency to pumping could be checked by varying the field excitation of the rotary transformers or by temporarily throwing a portion of the load on the storage battery. Only once in the past three years has the pumping been such as to cause any serious interruption. The switchboard at the substation was originally arranged to give the greatest possible flexibility in operation. Both rotaries could be run in multiple with the battery, or both rotaries could be run in multiple, feeding into the line, and the excess of current used to charge the battery; or one rotary could be run on the line and the second rotary used to charge the battery independently. This last method of operation was found impracticable, although at times desirable. Under this condition the pumping would immediately begin, and it necessitated giving up this method of operation. Notwithstanding the above-mentioned difficulties, when a year ago it was decided to increase the direct-current machinery we had gained sufficient confidence in the rotary system of 60 cycles to purchase a 400-kilowatt rotary rather than a direct-current generator.

The third rotary, when tested, proved to be free from any tendency toward pumping, either when operated from the steam plant or from the water power, and was in every way as nearly perfect as a machine could be. However, when thrown on the line with the two older rotaries, they immediately began pumping, and it was found impossible to run the three rotaries together. The pumping in a rotary system seems to be cumulative; it is very easy to stop it if the proper remedy is applied as soon as the first tendency to pump is noticed. If allowed to go on it quickly gets beyond control. The impossibility of running the three rotaries together necessitated some change. The Westinghouse company's engineers maintained that the corrective device could be applied with equal effect to any one of the three rotaries. Copper strips were attached to the pole-pieces of the 400-kilowatt rotary. This rotary, of itself, was all right, but the developing of any tendency of the system towards pumping was entirely overcome by means of these copper strips. The system now works perfectly, whether operated by steam or water power. Even under the trying conditions of running the rotaries under different voltages, two feeding directly into the line and the third independently charging the battery, no trouble with pumping is experienced. In all other respects the rotary transformers have been all that could be asked for; they have run practically continuously night and day for nearly three years, and have had practically no repairs, the commutators simply being turned down once or twice a year.

[The "pumping" of rotary converters or synchronous motors, and an effective means of accomplishing its prevention are discussed in a United States patent issued to B. J. Lamme on May 30th, wherein it is stated that the immediate cause of all such irregular action may be primarily due to irregular speed of the generator, to difference in form of the electromotive force waves of the generator and of the motor or rotary converter, etc. The immediate cause of the pumping lies largely in the distortion of the field of the motor or transformer when its armature has been forced for an instant to run at a speed either slightly greater or slightly less than the normal or synchronous speed. This distortion of the field of the machines may be explained as follows: If the armature of either an alternating or direct-current generator or motor is carrying current, its ampere-turns have a cross-magnetizing effect on the pole tips or edges which tends to straighten one edge and weaken the other. The resultant field is thus shifted either forward or backward, depending on the action of the current. In the case of a synchronous motor at no load, there should be very little armature current, and therefore a small distortion of the field. If the speed is suddenly changed, however, the motor armature will take considerable current, the resulting field will be shifted, and the armature will tend to move into a new position. In doing this, the field distortion, wave form, etc., are somewhat changed. The armature takes a current in the opposite direction for an instant, so that if in the first case, it receives current as a motor, it begins to deliver power for an instant. This distorts the field in the opposite direction, and the armature tends to swing the other way. If in the one case it was accelerating in speed, in the other it begins to drop in speed. Thus the armature may get into a sort of oscillation relative to the normal or synchronous speed, and this oscillation or "pumping" may be very small for a time, and gradually increase until it is so violent that the machine is thrown out of step with the system. The armature current due to the pumping is in turn a leading and lagging current, which tends alternately to strengthen and weaken the field magnetism. The field current will also oscillate with the pumping of the armature. In a rotary converter when an oscillation is started, incoming current represents more ampere turns than the current delivered, which will produce distortion as in a synchronous motor, and as the field alternately strengthens and weakens, the electromotive force varies, and the transformer pumps.

The patent specifications point out a method, known to be that of the Westinghouse Electric and Manufacturing Company, as installed in the Hartford and several rotary plants, for the prevention of this alternate distortion, which is done by placing copper shields or plates over or around the pole tips or edges, and copper rings around the ends of the pole pieces. If these shields and rings are of sufficient section and properly placed, the alternate distortion of the field at the tips or edges of the pole pieces will set up secondary currents in the shields and rings, which will oppose the distortion and neutralize its effect. Thus, when employed in connection with a rotary converter, they will, by neutralizing the magnetizing and demagnetizing effects of the armature currents, assist the machine to deliver a smooth direct current; and further, if the electromotive force waves of the generator and rotary converter are alike in form, the closed rings and shields acting as a secondary to the magnetizing and demagnetizing effects of the armature current, will tend to prevent injurious effects by reason of the flow of current between the two machines. The device illustrated in the patent consists of a flat strip of copper placed axially on each edge of the pole face, and a heavy ring of copper about each polar projection.—ED.]

---

*Abstract of a paper read before the Twenty-second Convention of the National Electric Light Association, New York, May 23-25, 1899.

A description of the Hartford transmission appears in *The Journal of Electricity* for November, 1898.

TRANSFORMER RATIOS EASILY DETERMINED.

A SIMPLE method of determining ratio of transformation in which errors of observation are eliminated, is due to J. R. Bibbins.* It requires the use of a single alternating-current voltmeter reading from zero to 150 volts, a source of alternating current (100 volts), and preferably a Pohls commutator, although the method may be applied without the commutator as the connections may be changed by hand. If the voltage of the alternating-current source is fairly constant, accurate results may be obtained without the use of a Pohls commutator, but if there is considerable fluctuation in voltage, its use will insure much more reliable results, as the voltmeter may then be transferred instantly from one circuit to another. The method has been used at the University of Michigan with great success.

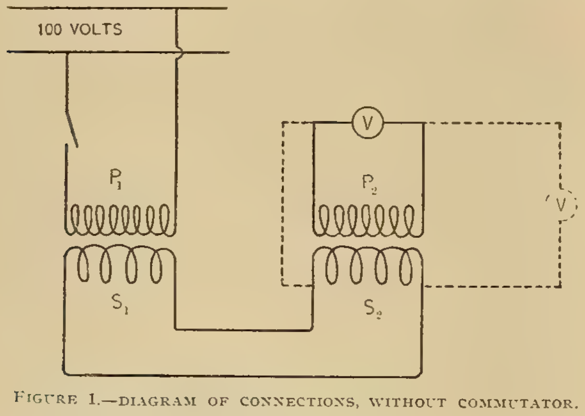


FIGURE 1.—DIAGRAM OF CONNECTIONS, WITHOUT COMMUTATOR.

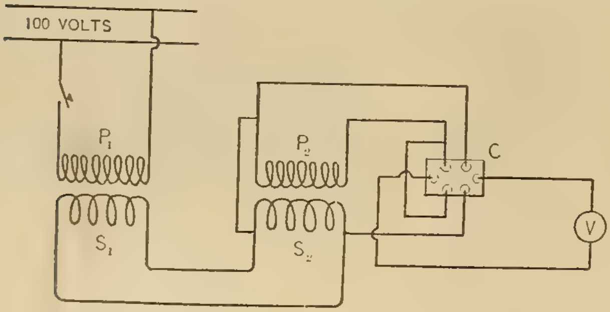
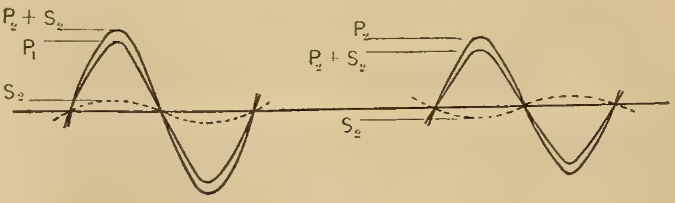


FIGURE 2.—DIAGRAM OF CONNECTIONS, WITH COMMUTATOR.

Referring to Figures 1 and 2, T_1 and T_2 are two transformers of approximately the same ratio of transformation, of which the ratio of T_2 is desired. Connect the two secondaries, S_1 and S_2, together, and the primary P_1 to the 100-volt mains or other source of alternating current with a switch-in circuit for convenience. First read the voltage at the terminals of P_2 (as indicated by the continuous lines in Figure 1), which will presumably be about 100 volts. Second, connect two terminals of P_2 and S_2, as indicated by the dotted portion of Figure 1. This should be either about 110 or 90 volts, depending upon which terminals are joined together. Assuming the values:



FIGURES 3 AND 4. TRANSFORMER PHASE RELATIONS.

$$P_1 = 100 \text{ volts}$$
$$P_2 = 102.6 \text{ ''}$$
$$P_2 + S_2 = 111.25 \text{ ''}$$
$$P_2 - S_2 = 93.95 \text{ ''}$$

Then ratio of T_2 =

$$\frac{P_2}{(P_2 + S_2) - P_2} = \frac{102.6}{111.25 - 102.6} = \frac{102.6}{8.65} = \frac{1}{11.861}$$

or ratio of transformation = 11.861. (1)

Or, again:

$$\frac{P_2}{P_2 - (P_2 - S_2)} = \frac{102.6}{102.6 - 93.95} = \frac{102.6}{8.65} = \frac{1}{11.861}$$

or ratio of transformation = 11.861. (2)

The identity of these results obtained in the above cases is explained thus: It is well known that at no load the primary and secondary electromotive forces of a transformer are displaced in phase 180°. If then S_2 is superposed upon P_2, as in Figure 1, whether S_2 will be subtracted or added to P_2 will depend on whether S_2 is in phase with P_2, as in Figure 3, or 180° behind it, as in Figure 4. That this feature is altogether immaterial is evident by observing that the dotted curve S_2 is derived in either figure by subtracting ordinates, and as only the numerical value of S_2 is required, the phase relations may be entirely disregarded.

The ratio of transformation of T_1 may be found in the same manner as that of T_2 by a simple interchange of position and connections.

CURRENT IN TWO AND THREE PHASE LINES.*

DETERMINING the current in the wires of two and three phase lines for a given number of kilowatts or horsepower, with a given voltage and power factor, is a problem requiring considerable calculation from the proper formula, all of which can be very readily replaced by the accompanying scales. Of these, Figure 1 gives the values for two-phase lines, and by multiplying by two gives the current strength for the same conditions on single-phase lines, while Figure 2 gives the current for three-phase lines. The formulas from which they were drawn are given with them.

The directions for their use are as follows: To find the current per phase for any output at any voltage, look up the vertical line corresponding to that output in kilowatts as determined by the horizontal scale running along the base of the intersecting squares. Follow this vertical line up to its intersection with the horizontal line corresponding to the voltage of the circuit, and the current strength in amperes will be found at the end of the diagonal current line intersecting that point. For example, upon the two-phase chart 50 kilowatts at 1100 volts shows approximately 22½ amperes per phase. In case the circuit is single-phase the number of amperes for this load at this voltage would be 45. If no diagonal line passes through the point of intersection the value of the current may be found by interpolation between the diagonal lines next above and below. For example, 70 kilowatts at 900 volts shows a current strength midway between 37½ and 40 amperes, or about 38¾ amperes. By noting the position of the decimal point any current at any voltage may be determined. For example, to determine the current at 2200 volts for a given load, the current at 220 volts may be read off from the chart and divided by 10; similarly, to determine the current for 500 kilowatts, 50 kilowatts may be applied to the chart and the result multiplied by 10.

---

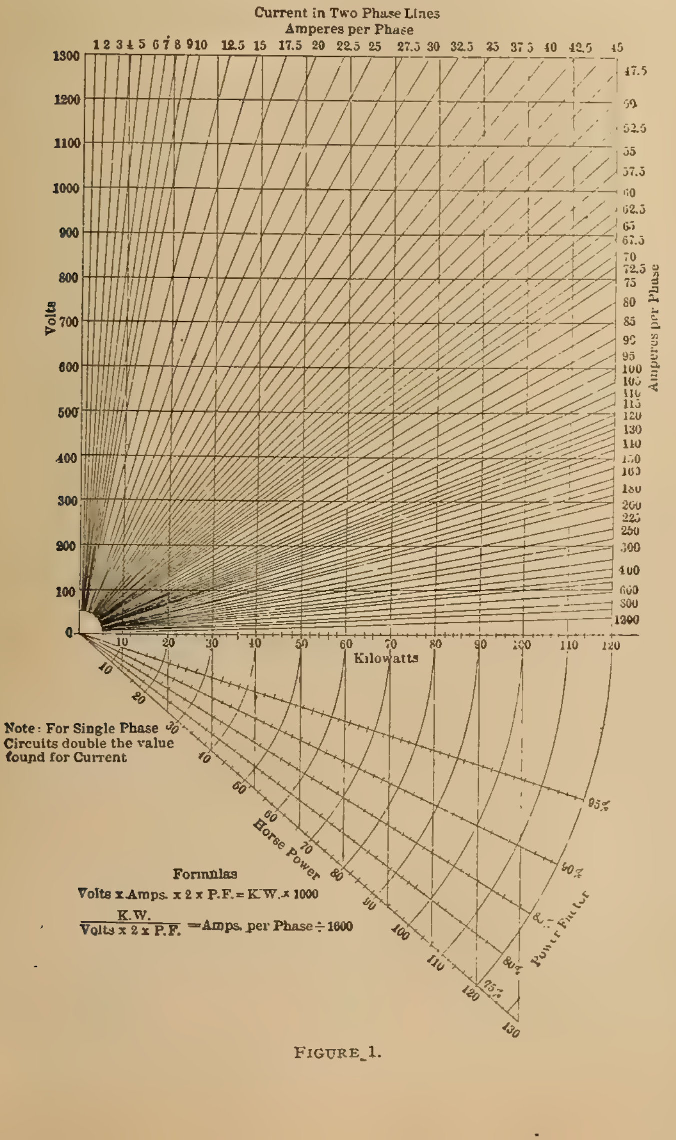
*Electrical World and Engineer, Vol. XXXIV, page 376.

*From the *American Electrician*, Vol. XI, page 391.

If the load is given in horsepower instead of kilowatts, it may be followed up vertically from the scale on the lowest radial line. For example, 80 horsepower at 600 volts gives 50 amperes.

The other radii are for use in case the power factor is less than unity. In this case the kilowatt line should be followed down vertically to its intersection with the radius representing the power factor of the circuit, and the circle intersecting this point should be traced around to the vertical and carried up into the scale of volts and kilowatts. For example, 70 kilowatts with a power factor of 80 per cent., shows an apparent load of 88 kilowatts, which may be followed up to, let us say, 1100 volts, giving 40 amperes.

By combining these various methods a given number of horsepower with a given power factor may be reduced to current. For example, 106 horsepower, followed up vertically, shows 80 kilowatts, which, with an 80 per cent. power factor, shows 100 apparent kilowatts and a current dependent upon the voltage as above pointed out. The chart is also reversible, a given number of amperes at a given voltage being readily reducible to kilowatts and horsepower if the power factor is known. For example, 70 amperes at 300 volts is evidently 43 kilowatts, or 56 horsepower, if it is non-inductive. If it has a power factor of 90 per cent., the same number of amperes at the same voltage becomes 39 kilowatts or 52 horsepower. The same methods are exactly applicable to the scale of three-phase systems.



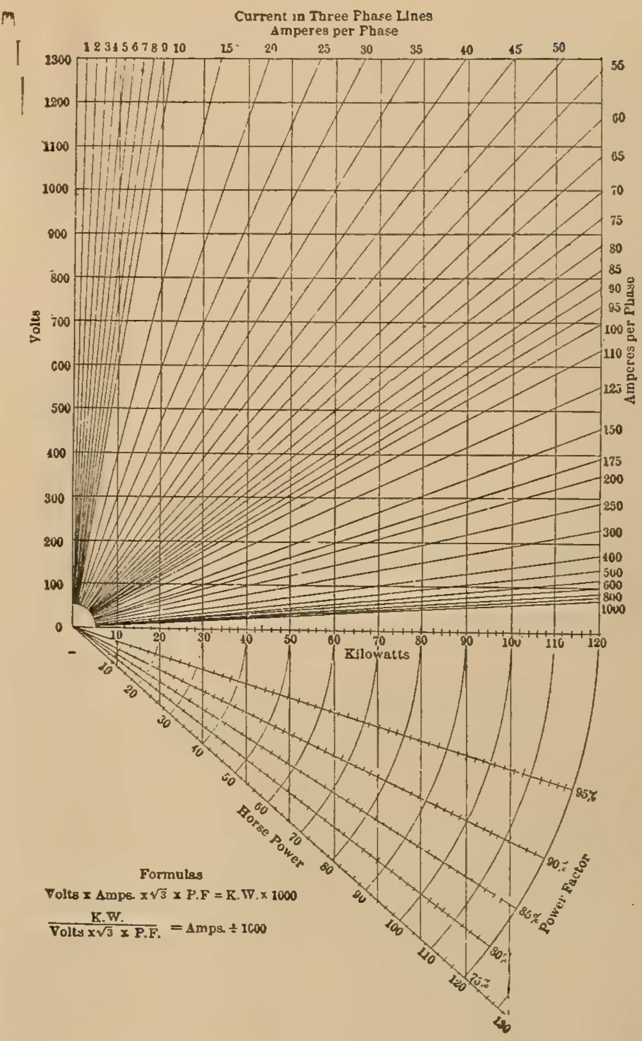
Note: For Single Phase Circuits double the value found for Current

Formulas

$$\text{Volts} \times \text{Amps.} \times 2 \times \text{P.F.} = \text{K.W.} \times 1000$$

$$\frac{\text{K.W.}}{\text{Volts} \times 2 \times \text{P.F.}} = \text{Amps. per Phase} \div 1600$$

FIGURE 1.



Formulas

$$\text{Volts} \times \text{Amps.} \times \sqrt{3} \times \text{P.F} = \text{K.W.} \times 1000$$

$$\frac{\text{K.W.}}{\text{Volts} \times \sqrt{3} \times \text{P.F.}} = \text{Amps.} \div 1000$$

FIGURE 2.

The lower diagonal or radial lines may be used to represent the efficiency of a motor in place of the power factor; for example, a 90 kilowatt motor having an efficiency of 90 per cent. would require 100 kilowatts to drive it, and the current required can be found as above.

These charts were drawn up by Stephen Q. Hayes, to whom indebtedness for their publication is acknowledged.

LOAD FACTORS AND GENERATION COSTS.

THE practical value of the load factor has been tested out during the operation of the three-phase system in Brooklyn, N. Y. At one time 2000-horsepower was shifted to and from the Union station from two of the large direct-current stations in such a way for each of two days the total generated kilowatts of the Union station remained exactly the same; but the load-factor during one of the days was 25 per cent. and during the other 80 per cent. Careful record was then kept of the cost of generation during the 24 hours of these two days in the Union station. It was found that when the load-factor of the station was 80 per cent., the cost was decreased 70 per cent. over what it was when the load factor was 25 per cent., the total kilowatt-hours of each of the two days being exactly the same.

"'Industrial Gas' promises to be a very interesting and valuable contribution to gas literature; send me your numbers for April, May and June containing it," writes Lewis A. Hicks, C. E., of Bakersfield, Cal., in a recent letter to the JOURNAL.

Distribution

SERVICE CHARGES AT A GLANCE.

QUICK and accurate means for the determination of power service charges for different periods of time each day and at different rates, are of great assistance to all managers, engineers and solicitors for electric power companies, and herewith are given, through the courtesy of C. N. Beal, six tables from which such service charges may be ascertained with celerity.

Electric power service is charged for on either the horsepower-hour, or on the kilowatt-hour basis; and, when yearly costs are considered, the annual service is for 313 or 365 days according to whether the service continues through Sunday or for but six days in the week. Seldom are conditions of installation and operation so favorable that electric power can be delivered at a rate of one cent per kilowatt-hour, although it is very rarely possible that conditions would warrant a rate as low as one-half cent per horsepower-hour, or its equivalent rate of .7602 cents per kilowatt-hour. The minimum rate considered under these tables is, therefore, the one last given, which appears in tables *E* and *F*. In all tables the rate advances by eighths and the range of each table is suf-

	Cents Per K.W. Hour.		Cost per K.W. Year of 365 Days of Hours viz:-							
			8	9	10	12	15	18	21	24
A	1		$29 20	32 85	36 50	43 80	54 75	65 70	76 65	87 60
B	1	125	32 85	36 96	41 06	49 27	61 59	73 91	86 22	98 55
C	1	25	36 50	41 07	45 62	54 75	68 43	82 12	95 81	109 50
D	1	375	40 15	45 17	50 18	60 22	75 27	90 33	105 39	120 45
E	1	5	43 80	49 28	54 75	65 70	82 12	98 55	114 97	131 40
F	1	625	47 45	53 39	59 31	71 17	88 96	106 77	124 53	142 35
G	1	75	51 10	57 50	63 87	76 65	95 80	114 98	134 14	153 30
H	1	875	54 75	61 60	68 43	82 12	102 64	123 19	143 71	164 25
J	2		58 40	65 70	73 00	87 60	109 48	131 40	153 29	175 20

TABLE A.

	Cents per HP. Hour		Cost per HP Year of 365 Days of Hours viz:-							
			8	9	10	12	15	18	21	24
A		746	$21 78	24 51	27 23	32 68	40 84	49 01	57 18	65 35
B		839	24 50	27 57	30 63	36 77	45 95	55 14	64 33	73 52
C		933	27 23	30 64	34 04	40 85	51 05	61 26	71 48	81 69
D	1	025	29 98	33 70	37 44	44 94	56 16	67 39	78 62	89 86
E	1	119	32 67	36 77	40 85	49 02	61 26	73 52	85 77	98 02
F	1	21	35 39	39 83	44 25	53 11	66 37	79 64	92 91	106 19
G	1	305	38 12	42 89	47 65	57 19	71 47	85 77	100 06	114 36
H	1	4	40 84	45 96	51 06	61 28	76 58	91 89	107 21	122 53
J	1	492	43 56	49 02	54 46	65 36	81 68	98 02	114 36	130 70

TABLE B.

	Cents Per K.W. Hour.		Cost per K.W. Year of 313 Days of Hours, viz:-							
			8	9	10	12	15	18	21	24
A	1		25 04	28 17	31 30	37 56	46 95	56 34	65 73	75 12
B	1	125	28 17	31 69	35 21	42 26	52 82	63 38	73 95	84 51
C	1	25	31 30	35 21	39 13	46 95	58 69	70 43	82 16	93 90
D	1	375	34 43	38 73	43 04	51 65	64 56	77 48	90 38	103 29
E	1	5	37 56	42 26	46 95	56 34	70 43	84 51	98 60	112 68
F	1	625	40 69	45 78	50 86	61 04	76 29	91 55	106 81	122 07
G	1	75	43 82	49 30	54 78	65 73	82 16	98 60	115 03	131 46
H	1	875	46 95	52 82	58 69	70 43	88 03	105 64	123 24	140 85
J	2		50 08	56 34	62 60	75 12	93 90	112 68	131 46	150 24

TABLE C.

	Cents per HP Hour.		Cost per HP Year of 313 Days of Hours, viz:-							
			8	9	10	12	15	18	21	24
A		746	18 68	21 02	23 35	28 02	35 02	42 03	49 03	56 04
B		839	21 02	23 65	26 27	31 52	39 40	47 28	55 16	63 04
C		933	23 35	26 28	29 19	35 03	43 78	52 54	61 29	70 05
D	1	025	25 69	28 90	32 11	38 53	48 15	57 79	67 42	77 06
E	1	119	28 02	31 53	35 03	42 03	52 53	63 05	73 55	84 06
F	1	21	30 36	34 16	37 94	45 53	56 91	68 30	79 68	91 07
G	1	305	32 69	36 79	40 86	49 04	61 29	73 55	85 81	98 07
H	1	4	35 03	39 41	43 78	52 54	65 66	78 81	91 93	105 08
J	1	492	37 36	42 04	46 70	56 04	70 04	84 06	98 06	112 08

TABLE D.

Cost in Cents per Hour		Cost per H.P. Year of 365 Days. Days Length in hours being, viz:-							
K.W.	H.P.	8	9	10	12	15	18	21	24
.6702	500	$14.60	16.43	18.25	21.90	27.38	32.85	38.33	43.80
.8378	.625	18.25	20.53	22.81	27.38	34.22	41.06	47.91	54.75
1.0054	750	21.90	24.64	27.38	32.85	41.06	49.28	57.49	65.70
1.1729	.875	25.55	28.74	31.94	38.33	47.91	57.49	67.07	76.65
1.3405	1.	29.20	32.85	36.50	43.80	54.75	65.70	76.65	87.60
1.5080	1.125	32.85	36.96	41.06	49.28	61.59	73.91	86.23	98.55
1.6756	1.250	36.50	41.06	45.63	54.75	68.44	82.13	95.81	109.50
1.8432	1.375	40.15	45.17	50.19	60.23	75.28	90.34	105.39	120.45
2.0107	1.500	43.80	49.27	54.75	65.70	81.12	98.55	114.97	131.40
2.1783	1.625	47.45	53.38	59.31	71.18	88.47	106.76	124.55	142.35
2.3458	1.750	51.10	57.49	63.88	76.65	95.81	114.98	134.14	153.30
2.5734	1.875	54.75	61.59	68.44	82.13	102.65	123.19	143.72	164.25
2.6810	2.	58.40	65.70	73.00	87.60	109.50	131.40	153.30	175.20

TABLE E.

Cost in Cents per Hour.		Cost per H.P. Year of 313 Days. Days Length being in hours, viz:							
K.W.	H.P.	8	9	10	12	15	18	21	24
.6702	.500	$12.52	14.09	15.65	18.78	23.48	28.17	32.87	37.55
.8378	.625	15.65	17.61	19.56	23.48	29.34	35.21	41.08	46.95
1.0054	.750	18.78	21.13	23.48	28.17	35.21	42.26	49.30	56.34
1.1729	.875	21.91	24.65	27.39	32.87	41.08	49.30	57.57	65.73
1.3405	1.	25.04	28.17	31.30	37.56	46.95	56.34	65.73	75.12
1.5080	1.125	28.17	31.69	35.21	42.26	52.82	63.38	74.95	84.51
1.6756	1.250	31.30	35.21	39.13	46.95	58.69	70.44	82.16	93.90
1.8432	1.375	34.43	38.73	43.04	51.65	64.56	77.48	90.38	103.29
2.0107	1.500	37.56	42.26	46.95	56.34	70.43	84.52	98.60	112.68
2.1783	1.625	40.69	45.78	50.86	61.03	76.29	91.56	106.81	122.07
2.3458	1.750	43.82	49.30	54.78	65.73	82.16	98.60	115.03	131.46
2.5134	1.875	46.95	52.87	58.69	70.43	88.03	105.64	123.24	140.85
2.6810	2.	50.08	56.34	62.60	75.12	93.90	112.68	131.46	150.24

TABLE F.

ficient to enable the result obtained from it to be applied as a factor in the determination of costs of service at rates other than those which appear in the tables. The length of days in hours is given under the cost-per-year heading, and these hours indicate the time of service per day.

It is obvious that the tables take no cognizance of load factor or of any sliding scale of rates graduating the costs down with increased consumption. They apply to the delivery of electric service on à straight kilowatt-hour basis. These and similar points are quite irrelevant to the tables for the reason that due consideration should be given to matters pertaining to load factors and consumption before quoting the rate in each specific case.

The tables are so simple that a detailed explanation of their mode of operation is believed to be unnecessary.

RECTIFICATION OF ALTERNATING CURRENTS.

VARIOUS arrangements of circuits which may be adopted in connection with alternate-current rectifiers having no moving parts—such, for example, as the electrolytic rectifier of Graetz and Pollak, which will be described later—are discussed by L. Kallir in a German electrical contemporary.* The cases considered by Kallir are shown in the annexed sketches, wherein the arrow affixed to each rectifier indicates the direction in which the current is allowed to flow, the rectifier itself being indicated by a circle containing an arrow.

The arrangement shown in Figure 1 is not to be recommended, as the current varies a great deal, reaching a zero value during each period.

In the opinion of the author, the connections of Figure 2 might be used with advantage for exciting the fields of an alternator, as the pulsations in the direct current therefrom are extremely slight.

Figure 3 shows an arrangement due to Graetz and Pollak, the characteristic feature of which is the utilization of *both* half-waves of the alternating current. In this case, and with a reasonable amount of inductance in the circuit, the pulsations are also slight.

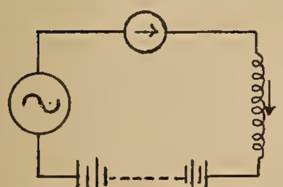


FIGURE 1.

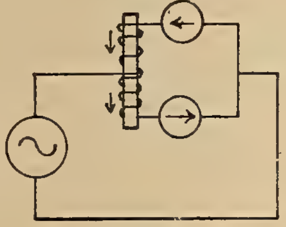


FIGURE 2.

Lastly, Figure 4 shows an arrangement adapted to three-phase circuit; the direct current from which may be rendered remarkably constant.

The Graetz and Pollak electrolytic rectifier, heretofore referred to, is based on the fact that when an anode of aluminum is employed in an electrolytic cell and the electrolyte is such that oxygen will be generated at this anode, the current passing will be reduced to an extraordinarily high degree. This is probably due to the formation of a low conducting film of oxide on the anode which increases the resistance of the circuit, and also to a kind of condenser action between the electrode and the liquid, or a di-electric polarization, as opposed to the ordinary electrolytic polarization. This latter view is based on the fact that each cell has a quite definite counter electromotive force of 22 volts, so that currents of lower potential do not pass through the cell. On reversing the current, however, the back electromotive force is less than one volt. The cathode may be of carbon, platinum, or any other usable metal except aluminum, and the electrolyte may be of any of the alum solutions (such as sodium-alum and potassium-alum solutions) or of dilute acids which generate oxygen on electrolysis.

If an alternating current be sent through a number of these cells arranged in series, the number being such that the polarization at the anode is greater than, or at least equal to, the potential of the alternating current, it follows that the positive impulse of the alternating current, in which the aluminum is the anode, is not allowed to pass through, while the negative impulse will pass through. In this manner an interrupted direct current is obtained of one-half the strength of the original alternating current, but the loss of one-half of its energy is not, however, involved in this.

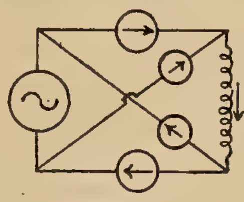


FIGURE 3.

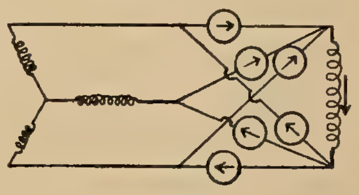


FIGURE 4.

By arranging another battery, having a similar number of cells but with its poles reversed, in parallel with the battery first mentioned, across the alternator terminals, the other half of the alternating current may be obtained as direct current, and the result is that a pulsating direct current then flows around the two branched circuits; that is, the positive current in one and the negative current in the other.

In a modified arrangement, a pair of oppositely-connected batteries are connected at each terminal of the alternating potential difference, and the other or opposite terminals of like batteries are connected together by conductors from which a direct current can be taken. By using sufficiently large cells so as to bring down the resistance as much as possible, a maximum energy efficiency of 95 per cent. can be obtained.

PURITY OF ALUMINUM.

MOISSAN, in referring to Ditte's experiments on an alloy of aluminum with about three per cent. of copper,* lays stress on the great influence exerted by the purity of aluminum on its resistance to corrosion, and on the importance of excluding the possibility of electrolytic action due to the contact of some other metal with aluminum.

Recent progress in the electro-metallurgy of aluminum has been accompanied by a notable improvement in the quality of the commercial metal produced, as is shown by the following table due to Minet.†

Composition of Commercial Aluminum.	In 1890.	In 1893.	In 1897.
	Per Cent.	Per Cent.	Per Cent.
Silicon	0.90	0.25	0.02
Iron	0.40	0.40	0.12
Aluminum	98.70	99.35	99.86

Since 1897 these traces of other metals in aluminum have been removed and the metal in its commercial form is now chemically pure.

ROTATIVE DIRECTION OF SYNCHRONOUS MOTORS.

Single-phase synchronous motors will run in either direction as started, but the rotative direction of polyphase synchronous motors is reversed under the same rules as apply in polyphase induction motors, which are given on page 40 of the August issue.

Chas. F. Scott, chief electrician of the Westinghouse Electric and Manufacturing Company, writes: "I want to congratulate you on the evident prosperity and the advancement which the JOURNAL is making as is indicated by the enlargement of its title. The full and exhaustive way in which you take up a thing makes the articles in the JOURNAL of especial interest and value."

---

*See *Science Abstracts*, No. 207, 1898, and No. 1090, 1899.

Science Abstracts, 1899, No. 1532.

†*Ibid.*, No. 1553.

THE JOURNAL OF
ELECTRICITY, POWER AND GAS
Devoted to the Conversion, Transmission, and Distribution of Energy.

Conducted by GEO. P. LOW.

Official Organ of the Pacific Coast Electric Transmission Association.

Yearly subscription: Domestic, $1.00; Foreign, $1.50, postage paid.

Entered as second-class matter at the San Francisco Post Office, August 15, 1899.

Entered as *The Electrical Journal*, July, 1895. Entry changed to *The Journal of Electricity*, September, 1895.

Published monthly at 320 California Street, San Francisco, Cal.
Address remittances and communications to
315 CHERRY STREET, [Telephone, "Pine 76"] SAN FRANCISCO, CAL.

VOLUME VIII OCTOBER, 1899 NUMBER 4

For Table of Contents see Page X.

EDITORIAL.

MUNICIPAL OWNERSHIP THERE AND HERE.

San Francisco and Oakland are sister cities, geographically, socially and commercially. The first has all that goes to make a metropolis frenzied in mad commercialism; the other is a charming suburb of all the beauty and sobriety that the term implies. The population of the one aspires to at least the half-million mark, while that of the other numbers close to one hundred thousand, but each is a city well worthy of the name. Each is also distraught with its own local issues. Oakland has, or has had itself involved in throes of excitement over matters of domestic import ranging in consequence from a determination of the fate of an anti-cigarette ordinance to the perennial agitation concerning its water frontage—all, however, of no greater interest to the world at large than are the interchanges of maternal sympathies and secrets across a back yard fence. But the nation has no greater interest in the politics of New York City than has the state of California in the affairs of San Francisco. Here are centered the largest commercial interests of the State, the densest population, and, not least, here are found most astute, subtle and even knavish of politicians—sage and sleepless devotees to Mammon that they are! More than this, the mystic shrines of this occult sect are currently believed to be not far removed from the general offices of the corporations which dispense to the patient public various utilities in the way of water, street-railway transportation, gas and electricity.

⁂

Political matters have no place in these columns. A presentation of the influences which they may exert for good or for evil upon the light, heat and power industry, or a discussion of the influences which the policy of quasi-public corporations may exert for good or for evil upon the potentialities of municipal or governmental exactions and regulations may not, however, be out of place. It has been said times without number that the emissaries of local corporations are the most potent of all political corruptionists, and no sincere denial of the charge has hitherto been made. Gas, street railway, electric and water companies, as a class, are, then, under arraignment as exercising pernicious and malicious influences. Just how far, locally, do facts warrant the accusations, just what are the situations in this respect in Oakland and San Francisco, and to what extent are these municipalities warranted in forebearing the exercise of their legal prerogatives in the acquirement of public commodities?

These are broad questions when applied to San Francisco—too broad, in fact, to receive consideration at this time—but Oakland presents an instance warranting an absolute denial of the charge, for, as will be shown, the conduct of its lighting monopoly at least has been exemplary.

⁂

In Oakland the attitude of the lighting company toward the public has been that of fairness even to liberality, of honesty even to philanthropy, and of public-spiritedness even to self-sacrifice. The fairness of the Oakland Gas, Light and Heat Company is evidenced by its voluntary reduction in rates with each improvement or new process it acquires; its honesty is attested by the fact that while costs of production of electric energy are no less than the ordinary figures, yet the rate for street lighting in Oakland is but about half of that charged in the near-by city—a difference so strikingly apparent that interested electrical concerns do not possess the effrontery to list the respective costs in their publications of schedules of prices paid for street lighting in the United States. Lastly, the public-spiritedness of the Oakland monopoly has been proved on many occasions, one only of which need be cited: In April last a serious deficit in city finances confronted the City Council of Oakland, and the city employees from mayor to the catcher of vagrant dogs accepted three-quarters pay for the remainder of the fiscal year to tide over the extremity. Still the treasury showed a deficit. The manager of the gas and electric company straightway appeared before the council and volunteered to execute the contract it held for lighting the city for a sum less by $5743 than the amount which the contract called for. A disclaimer to that amount under the contract was duly filed, "and," continued the manager in his address before the council, "we are prepared to go further. We will, if you find your deficit increase beyond present estimates, consent to further reductions after the same manner."

⁂

The lighting monopoly of Oakland has, then, never made itself liable to the charge of corrupting politics. More than this, so long as its present policy is preserved, not only would municipal ownership be an absurdity, but successful competition will be an exceedingly difficult, if not impossible, task.

⁂

Municipal ownership has no place in Oakland for the reasons stated. In San Francisco it may and undoubtedly will be well for the city to fortify its future welfare against corporate greed by venturing upon the experiment of municipal ownership to the extent of owning its own pole lines and such circuits as are necessary for the lighting of the streets, municipal buildings and public places. Such ownership will insure legitimate and plentiful competition for all time; *it will make a net reduction in the cost of street lighting by nearly, if not quite, fifty per cent.;* it will eliminate all the monstrous element of perplexity which attends the administration of engineering affairs by unfitted political roustabouts; and it will forever make it impossible for San Francisco to again feel chagrined in the knowledge that for years and years, had it but known it, the *open sesame* to fifty per cent. rates has been the mere existence of *a competitive circuit to the point of service.* San Francisco found that the cost of lighting the City Hall was reduced just one-half for no other reason than that the mains of the Mutual company had at last reached that building. San Francisco will find that the cost of its street lighting will be reduced a similar amount by no other exercise of the right of municipal ownership than the building of the pole line aforesaid. And this is for the simple reason that no new company, however strong, can afford to build these city lighting circuits on the gauzy prospect of securing the city contract for a single year.

Here then, is San Francisco's golden opportunity for municipal ownership.

⁂

Under its new charter, if wisely administered, San Francisco may find amelioration from the pernicious influences that have ever been exerted toward perpetuating the present conditions and prices under which the contracts for lighting its streets and public buildings are awarded. The JOURNAL will always be found staunch in its advocacy of fair returns upon honest capitalization. It will ever contest exorbitant rates as earnestly as it will decry ruinous competition, and it will find no dearth of words to express its denunciation of any course that may be taken toward throttling legitimate competition to the detriment both of the public weal and of the general welfare of the industries the JOURNAL represents.

IMPOUND THE STATE'S FLOOD WATERS!

What is the matter with some of the electrical journals of the American metropolis? One of them, in discussing the effect of water power development on the industries of California, observes:

> At present there are eleven enterprises in California which are utilizing the formerly wasted water power of the mountain streams for the production of electrical energy, the most important being the plant at Folsom, where 45,000 horsepower is generated and transmitted twenty-four miles to Sacramento; the San Gabriel Electric Power Company's plant which delivers 6000 horsepower to Los Angeles, a distance of twenty-seven miles; and the San Joaquin Electric Company's plant by means of which several thousand horsepower of electrical energy is transmitted to Fresno and neighboring towns.

Then again, another New York electrical journal says:

> One hundred and fifty thousand horsepower of energy is to be supplied to the city of San Francisco from Blue Lakes, 150 miles away. The total output of the plant has been contracted for in advance by San Francisco parties, customers of the Standard Electric Company of that city. The system adopted is the Stanley, of Pittsfield, Mass., and the work of installing will proceed as rapidly as possible, the contract for the apparatus having been entered into a few days ago.

Truly, we must go from home to get news. We who are on the ground and who are reputed to be familiar with things as they be, are disposed to believe that one cipher too many has been added to the statement alleging the capacity of the Folsom plant; also that if still another cipher be dropped from the corrected figure, close to the truth will then be had as to the twenty-four-hour load which the Folsom plant delivered last summer. The fact is that the Folsom station was then running only by night upon water conserved during the day; the steam auxiliary plant at the sub-station in Sacramento was being run to full capacity by day and partly during the night, while the Yuba Electric Power Company delivered 1000 continuous horsepower, day and night, to the Sacramento sub-station. The plant of the Capital Gas Company, which has been acquired by the owners of the Folsom-Sacramento transmission, is carrying the arc lighting load of the city. As to San Gabriel, the transmission plant has an installation of only 2200 horsepower in water wheels, and during the drouth it delivered less than one-fourth of that amount of power for the simple reason that, as with Folsom, Fresno and other transmissions, it was short of water. And poor Fresno! It shut off its power service and street lights, and its newly-appointed receiver would doubtless be glad to know that he could rely on having several hundred horsepower, to say nothing of the several thousand horsepower which the plant is reputed to be delivering—incidentally from three 340-kilowatt generators! In the Blue Lakes-San Francisco transmission, too, the capacity has been multiplied by ten, for the initial installation will be in the neighborhood of 15,000 horsepower, and not 150,000 horsepower as stated.

⁂

We will not arraign our esteemed metropolitan contemporaries, for surely the enchantment of distance has placed them under magic spell. But capital and the engineering world want fact, and only fact—and fact they shall ever have in these columns.

Then do not misunderstand the motive which underlies the publication of the cold, hard truth concerning the water supplies of some of the electric transmissions of California. For more than two years now the Golden State has suffered from drouth. Its mountains were snowless; many of its rivers were dry or nearly so; its great valleys were parched, except in favored localities, and its mining and transmission interests were, in the main, badly crippled from lack of water. Some transmissions, notably those on the Yubas and on the Kern and Kaweah rivers, have been favored with supplies of water which have been phenomenal, considering the seasons, but others have found that the only alternative from virtual shut-down has been the erection and operation of auxiliary steam plants.

And all this drouth and crippling of industries occurs in a country where, even in periods of drouth, the flood gates of heaven open at times and the dry beds of the rivers become for a day filled to the brink with raging torrents which oftentimes wash out levees and inundate hundreds of square miles of farming lands. Then in a day or two more, the river beds are almost as dry again as ever, for the mad rivers have spent their fury in the sea. This is not a fanciful picture, for should a tithe of the waters that rush down the canyons of the Sierras even during periods of so-called drouth be impounded in mountain storage reservoirs, all the transmission and mining plants which the coming generation may install would never know want of water.

⁂

A remedy for this most unfortunate condition—for the deep mining and electrical transmission interests of the State find their main difficulty in operation to lie in the unreliability of water supply—is found in the suggestion implied at the end of the preceding paragraph; namely: IMPOUND THE FLOOD WATERS OF THE STATE!

It is gratifying to know that the seriousness of the problem is at last fully realized by many of the most prominent business men of California, and that this recognition, which has long lain dormant, has now assumed tangible form in the organization of the California State Association for the Storage of Flood Waters, a committee of which is now preparing an address to the people of the State setting forth the objects of the Association and of the convention of delegates which is to be held in San Francisco on November 14th. Among the members of this committee appears the name of Dr. Thomas Addison, manager of the San Francisco office of the General Electric Company, and president of the Sacramento Electric Railway and Gas Company.

Some estimate of the necessity for attaining the objects of the Association may be had from the recent remarks of Mr. W. C. Ralston, vice-president of the California State Miners' Association, to the effect that the drouth during the winter of 1897-98 had at the most conservative estimate caused a loss of $7,000,000 to the miners alone, and all the way from $25,000,000 to $30,000,000 to the farmers and orchardists of the State.

MEASURING DYNAMO EFFICIENCIES.

To the subscriber who asks the JOURNAL to describe a simple method for measuring dynamo efficiencies, it may be stated that the determination of the efficiency of direct-current dynamos and of alternators having good regulation, involves the consideration of three elements of loss; *viz.:* iron loss, copper losses and friction losses. Of these losses, those due to iron and friction are practically constant under all conditions of load, while the copper losses increase directly with the load according to the square of the current (C^2R) in field and armature, separately considered. These factors of the total loss may be easily determined by driving the dynamo from an electric motor preferably through direct connection, and measuring the net power applied to the motor by means of an indicating wattmeter, the term "net power" signifying the difference between the watts required to drive the motor with and without the load.

The iron loss of the fields is inconsequential. The iron loss of the armature core is found in the difference between the net wattage used in driving the motor (1) when the armature of the dynamo is at normal speed and the field charge gives normal voltage from the armature; and (2) when the armature is at normal speed with no field charge.

The friction and windage loss is expressed in the net watts consumed by the motor in driving the armature at normal speed without field charge.

The copper losses in armature and field coils are expressed in the watts derived by multiplying the square of the current by the resistance (C^2R), care being taken to calculate the resistance of the copper at the running temperature.

The sum of these losses is the total loss in watts, and the output of the dynamo at any load, divided by such output plus the total loss at that load, gives the commercial efficiency of the dynamo.

Gas

INDUSTRIAL GAS.—VII.

BY FRANK H. BATES.

COLLECTION OF SAMPLES. The method to adopt in collecting a gas sample is dependent upon the conditions under which one is operating. The first point to be observed is to use such means as will give a sample representing the average gas. Oftentimes in the gases to be sampled there exist currents whose composition vary considerably, this being especially true in the case of chemical processes and furnace gases. In such instances some ingenuity must be exercised to meet the special conditions.

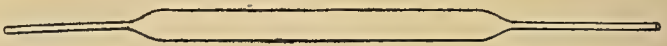


FIGURE 21.

For the retention of a gas sample, the collection tube shown in Figure 21 will serve. The ends are made quite long and drawn down to about two millimeters ($\frac{1}{16}$-inch) internal diameter. They should be of about 200 cubic centimeters capacity. It will be found very convenient for transportation to have a box, provided with separate compartments, to hold about a dozen of these tubes. To take a sample it is simply necessary to connect, by a short rubber tube, at one end to the gas supply, allowing the gas to flow through (the gas being under pressure) till certain that all air has been expelled and that only pure gas remains; then almost stopping the flow to relieve the

FIGURE 22.

tube of pressure, seal near the end by holding a lighted candle to it, or by means of an improvised blowpipe made by pointing and nearly closing the end of a glass tube, and then bending near the point, cutting off at a convenient length.

The collection tube will serve for a number of samples before becoming so short as to make it necessary to weld on new ends.

A somewhat handier tube is shown in Figure 22, having glass stop-cocks, which obviates the necessity of sealing by heat. Although there is but little liability to leakage with these tubes when the ground glass stop-cocks fit properly and are kept well greased, yet the writer has made it a practice, when obliged to retain the sample some time before making the analyses, to cover all joints and the open ends with sealing wax, which renders leakage impossible. A case of these collection tubes is shown in Figure 23. Instead of water for the confining liquid, mercury is often used when the previous saturation of the water is inconvenient or for other reasons.

It is sometimes desirable to obtain a sample of a gas passing through a conduit of some kind, which may represent the average gas for a certain period of time. For such purpose the apparatus illustrated by Figure 24 is well suited. The tanks A and B are constructed of galvanized iron, and measure some 12 inches in diameter and 18 inches in length, one being slightly longer than the other. Bottoms and tops of the tanks should be slightly curved downwards and upwards respectively, to render it possible to secure complete drainage. At about the center of both top and bottom is inserted a ¼-inch gas pipe nipple, the joint being strongly soldered, on which are screwed pet-cocks for the tops and pipe connections to the outside for the bottoms, there being a rim sufficient to raise the tank above the piping. Pet-cocks are put on the lower pipes at a convenient distance from the side. On the tops there are also auxiliary nipples with pet-cocks attached, to allow of rapid filling.

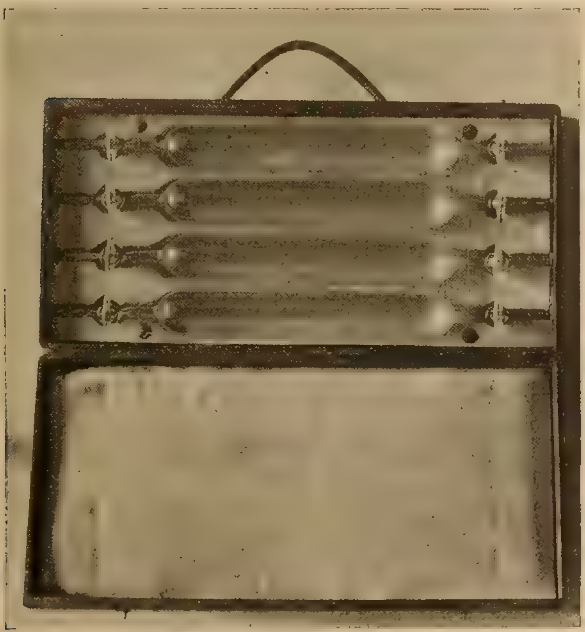


FIGURE 23.

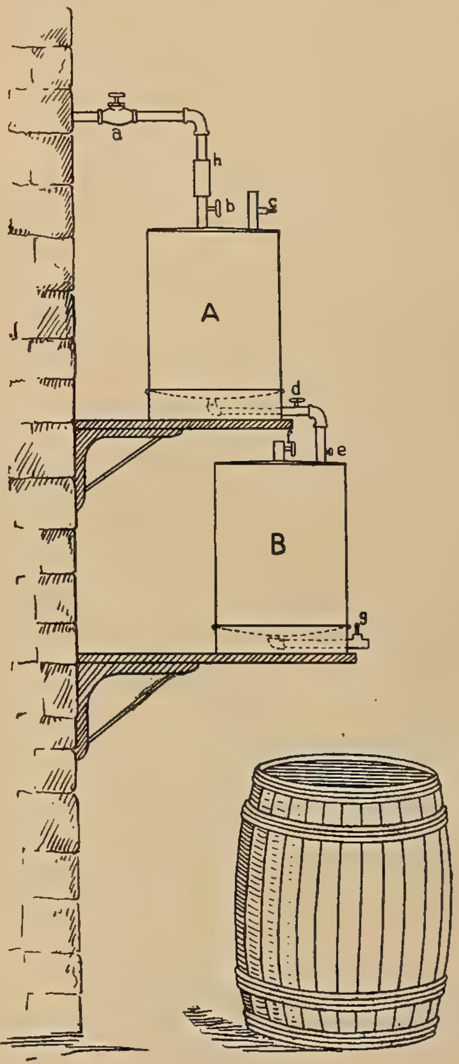


FIGURE 24.

Operation. The upper (larger) tank is first filled with water and then connected to the gas source by suitable means, while on a shelf below, and with its auxiliary pet-cock connected by rubber tubing to the outlet from the upper tank, is placed the smaller one. By turning on the globe valve *a* (on the pipe leading to the gas source) and opening pet-cocks *b*, *d*, *e* and *f*, and with pet-cocks *c* and *g* closed, allow the water to run from the tank A into tank B, displacing the air from the latter and causing it to issue from the open pet-cock *f*. As the water recedes from the tank A, a partial vacuum is created which causes the gas to rush in. The receding water, mingling with the inrushing gas, becomes thoroughly saturated and is used to fill the lower tank B. On the overflow of water from the pet-cock of the tank B, pet-cocks *f* and *e* are closed, and the tank is disconnected from the upper one (which is removed), and connected up to the gas source by attaching the rubber tube *h* to the pet-cock *f*. With a long rubber tube attached to the outlet pet-cock *g*, to serve as a drain to the waste barrel, open the pet-cocks *f* and *g*, causing the water to run from *g* and draw in the gas through *f*. By adjusting these pet-cocks, the time taken to fill the tank may be lengthened or shortened, so that an average sample of a run of a certain duration may be obtained. The previous saturation of the water used prevents the washing out of the soluble constituents of the gas.

The kind of piping to use for running into the furnace or holder will depend upon the temperature and nature of the gases. With a high temperature iron tubes with ample water-jacketing should be employed.* Porcelain, glass or platinum tubes may also be used. Where the gases are strongly acid and the time occupied in making the collection is long, only glass tubes should be employed; they will not be affected by temperatures within 600° C. At temperatures lower than 300° C., lead piping will be found serviceable owing to its great flexibility. Since vulcanized rubber tends to absorb the gases, rubber tubing of any length should be avoided.

In a single flue, way or conduit from which the sample is being drawn, there are often found currents of some strength and of quite different composition, necessitating, therefore, the use of several branches of piping to penetrate equally all parts and thus afford a fair average. Where the current in the flue way is strong, a suction pump or siphon may be employed to advantage.

For collecting gases from mines, etc., the form of tank shown in Figure 24 may also be used. For this purpose fill with water and place in an upright position where it is desired to sample the gas. By opening both lower and upper pet-cocks cause the gas to replace the water. As soon as the tank empties of water, close all pet-cocks enclosing the sample.

For packing used in making tight joints, asbestos is probably the best, although, under certain conditions, putty, plaster of Paris, or wet waste may be used.

MEASUREMENT OF GASES.

Correction for Temperature, Pressure and Vapor Tension.

Owing to the fact that the volume of a gas varies with change of pressure and temperature, it is necessary to reduce volumes measured under different conditions to some set standard in order that a true comparison may be arrived at. Universal custom has determined this standard as 760 millimeters (29.92158 inches) of mercury for pressure, and 0° C. (32° F.), for temperature; hence by reducing to these conditions, gases of similar composition will always be of equal mass or weight per unit of volume or of equal volume per unit of mass or weight. With this understanding, we may speak of one liter of a certain gas as always having the same mass or weight, and likewise of one gram as always having the same volume, knowing that under like conditions of pressure and temperature there will exist a constant relation between volume and mass.

The pressure acting upon a gas is generally measured in millimeters or inches of mercury: that is, in terms of the height of a column of mercury which it sustains; thus the atmospheric pressure is read from a barometer as so many millimeters or inches of mercury.

In determining the volume of a gas, therefore, it is necessary to consider the conditions under which it is measured. If in an open vessel or in a vessel over a liquid, as mercury or water, in which the level of the liquid is the same inside as it is outside the vessel, then a reading of the barometer, giving the atmospheric pressure, likewise gives the pressure acting upon the gas.

To measure a gas under atmospheric pressure it is only necessary therefore, to confine it in a vessel over a liquid by means of a level tube, and adjust the tube so as to bring the level of the liquid both inside the vessel and in the level tube to the same height, for should the level of the liquid within the vessel be higher than in the tube, the gas will be under diminished pressure, and if, on the other hand, it is lower than in the tube, it will be under a pressure greater than atmospheric, due to the weight of the column of liquid above its level. In Figure 25, if mercury be used for the confining liquid in a level-tube A′ open to the atmosphere, and a measuring burette A closed at the upper end by a pinch-cock, then it is evident that with the levels of the mercury at *a′* and *a* in the level-tube and measuring burette respectively, the gas enclosed in the latter above the mercury is not exerting as great a pressure as is the atmosphere on the liquid at the open end of the level-tube where the level is the lowest. The pressure upon the gas is equal in this case to the atmospheric less 15 millimeters, the distance between the levels, which equals, with an atmospheric pressure of 760 millimeters, 745 millimeters of mercury as actual pressure.

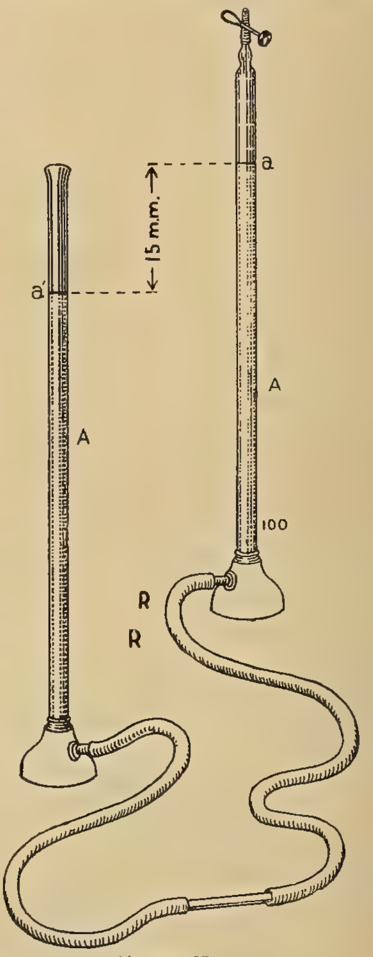


FIGURE 25.

Were the case reversed, that is, were the level *a* 15 millimeters lower than the level *a′*, then the pressure on the gas would equal 760 + 15, or 775 millimeters of mercury.

If water is employed as the confining liquid instead of mercury, it will be necessary to determine the pressure in terms of mercury in order to make use of the barometer and standard conditions. Mercury has a specific gravity of 13.6; that is, the weight of a given volume of water is but $^{1}/_{13.6}$ part of the weight of an equal volume of mercury. In the foregoing example, had the liquid been water, with the same pressure acting upon the gas, there would have been a difference of level of about 204 millimeters of water, which, divided by 13.6 would give the 15 millimeters of mercury.

---

*Iron piping, if raised to a temperature of redness, may alter the gas composition, since the oxygen of the iron oxide (iron rust) will combine with the unsatisfied carbon monoxide to form carbon dioxide.

Influence of Pressure on Volume. What is known as Boyle's law states that *the volume of a perfect gas varies inversely as the pressure it supports;* that is, the greater the pressure the less the volume. The following example will serve to illustrate this:

A volume of ethylene, C_2H_4, measures two liters under a pressure of 750 millimeters of mercury. What would its volume be under standard conditions of pressure, temperature being neglected?

Standard pressure is 760 millimeters of mercury; consequently we are to determine the volume under an increased pressure, which, by the law of Boyle, will give us a smaller volume. Thus:

760 mm. : 750 mm. :: 2 litres : X (the required volume)

$$\text{or, } 2 \times \frac{750}{760} = X; \text{ or, } X = 1.9 \text{ liters;}$$

that is, the volume under standard conditions of pressure will be 1.9 liters. Conversely:

A volume of ethylene, C_2H_4, measures 1.9 liters under a pressure of 760 millimeters of mercury. What would its volume be under a pressure of 750 millimeters, temperature being neglected?

It is here required to ascertain what the volume of a gas, measured under standard conditions of pressure, would be under a given decreased pressure, which, by the law, will give a greater volume. Thus:

750 mm. : 760 mm. :: 1.9 (liters) : X (required volume)

$$\text{or, } 1.9 \times \frac{760}{750} = X; \text{ or, } X = 2 \text{ liters.}$$

The above operations may be stated more briefly in the following rule:

Multiply the volume actually measured by a fraction whose numerator and denominator will be the absolute pressures, the greater of which will be the denominator or numerator according as the volume is to be decreased or increased, which may be seen by an inspection of the problem and an understanding of Boyle's law.

Influence of Temperature on Volume. Actual experiment has proven that all gases have the same coefficient of expansion by heat. In the centigrade scale the coefficient of expansion per degree is 0.003665, or, expressed in fractional form, $^1/_{273}$; that is, the pressure being constant, the volume of a perfect gas increases $^1/_{273}$ of its volume at 0° C., for every increase in temperature of 1° C., and in Fahrenheit units 0.002036, or $^1/_{491.2}$ of its volume at 32° F., for every increase of 1° F. Likewise it decreases for each negative degree.

It follows, then, that the volume at

$1°$ C. = vol. at $0°$ C. + $\frac{1}{273}$ (vol. at $0°$ C.) = $\frac{274}{273}$ (vol. at $0°$ C.)

$2°$ C. = vol. at $0°$ C. + $\frac{2}{273}$ (vol. at $0°$ C.) = $\frac{275}{273}$ (vol. at $0°$ C.)

$3°$ C. = vol. at $0°$ C. + $\frac{3}{273}$ (vol. at $0°$ C.) = $\frac{276}{273}$ (vol. at $0°$ C.)

$t°$ C. = vol. at $0°$ C. + $\frac{t}{273}$ (vol. at $0°$ C.) = $\frac{273 \text{ plus } t}{273}$ (vol. at $0°$ C.)

and the volume at

$-1°$ C. = vol. at $0°$ C. — $\frac{1}{273}$ (vol. at $0°$ C.) = $\frac{272}{273}$ (vol. at $0°$ C.)

$-2°$ C. = vol. at $0°$ C. — $\frac{2}{273}$ (vol. at $0°$ C.) = $\frac{271}{273}$ (vol. at $0°$ C.)

$-3°$ C. = vol. at $0°$ C. — $\frac{3}{273}$ (vol. at $0°$ C.) — $\frac{270}{273}$ (vol. at $0°$ C.)

and at

$-273°$ = vol. at $0°$ C — $\frac{273}{273}$ (vol. at $0°$ C.) = $\frac{0}{273}$ (vol. at $0°$ C.)

that is, at — 273°, by the law, the gas would entirely disappear or be of no volume, which would be impossible. To account for this apparent discrepancy in the law governing the effect of temperature on perfect gases, we find that as gases approach the temperature of liquification, their properties change from those of a perfect gas and thus they deviate from the law. In order to facilitate computation, however, the temperature of —273° C. is considered as absolute zero. To obtain absolute temperature, therefore, *add 273° to the readings of the Centigrade thermometer, or 459.2° (= 491.2 — 32)—generally taken as 460°—to the readings of the Fahrenheit thermometer.*

From the foregoing it is readily seen that if a volume of gas measured 273 cubic centimeters at 0° C., (which is 273° C. absolute temperature), and was raised one degree, bringing the absolute temperature to 274° C., the volume would be increased $^1/_{273}$ of the volume at 0° C., or the volume would become 273 + 1 = 274 cubic centimeters; and similarly, if raised 5° C., the volume would become 273 + 5 = 278 cubic centimeters. We may therefore restate the law, known as that of Charles, as follows:

The volume of a gas varies directly as its absolute temperature; that is, the greater the temperature, the greater the volume, and the less the temperature, the less the volume.

The following example will serve to illustrate the use of this law:

A volume of ethylene, C_2H_4, measures two liters at a temperature of 21° C. (69.8° F.). What would the volume be under standard conditions of temperature, pressure being neglected?

Standard temperature is 0° C.; consequently we are to determine the volume under decreased temperature, which by the above law, will give a decreased volume. Thus:

Reducing all temperatures to absolute
21° C. = 273 + 21 = 294° C. absolute
0° C. = 273° C. absolute; then,
294° C. : 273° C. :: 2 (liters) : X (required volume)

$$\text{or, } 2 \times \frac{273}{274} = X; \text{ or, } X = 1.8 \text{ liters;}$$

that is, the volume under standard conditions of temperature will be 1.8 liters. Conversely:

A volume of ethylene, C_2H_4, measures 1.8 liters at a temperature of 0° C., what would the volume be under a temperature of 21° C., pressure being neglected?

It is here required to ascertain what the volume of a gas, measured under standard conditions of temperature, would be at a given increased pressure, which by the law, will give an increased volume. Thus:

Reducing all temperatures to absolute
0° C. = 273° C. absolute
21° C. = 273 + 21 = 294° C. absolute; then,
273° C. : 294° C. :: 1.8 (liters) : X (required volume)

$$1.8 \times \frac{294}{273} = X; \text{ or, } X = 2 \text{ liters};$$

that is, the volume at a temperature of 21° C., will be two liters.

As in the case of pressure, operations may be shortened by the following rule:

Multiply the volume actually measured by a fraction whose numerator and denominator will be absolute temperatures, the greater of which will be the denominator or numerator, according as whether the volume is to be decreased or increased, which may be seen by a simple inspection of the problem and understanding of Charles' law.

The application of the laws for both pressure and temperature may be combined in one operation. Taking the example:

A volume of ethylene, C_2H_4, measures two liters under a pressure of 750 millimeters of mercury and at a temperature of 21° C., what will be the volume under standard conditions of pressure and temperature?

Pressure measured under = 750 millimeters
Standard pressure = 760 millimeters
Temperature measured under = 21° C. = 273 + 21 = 294° C., absolute.
Standard temperature = 0° C. = 273° C.

As the pressure is to be increased, its effect will be to diminish the volume. As the temperature is to be decreased, its effect will be to diminish the volume also, consequently we have

$$2 \times \frac{750}{790} \times \frac{273}{294} = X; \text{ or, } X = 1.83 \text{ liters.}$$

(Continuation in next number.)

Telegraphy

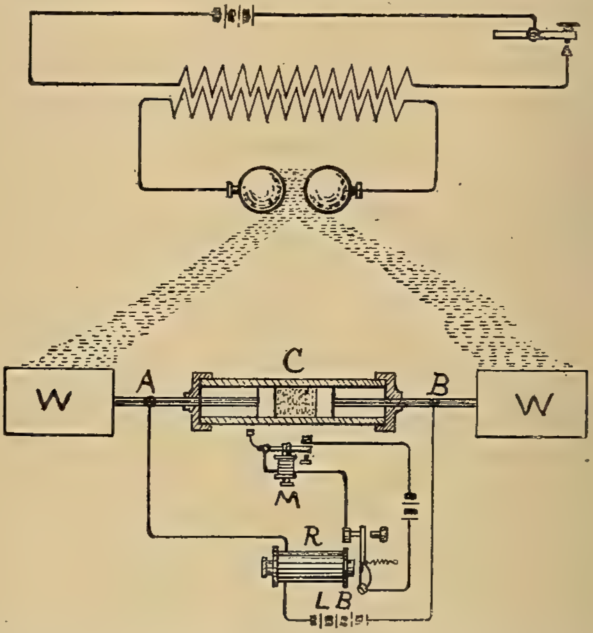
THE PRINCIPLE OF WIRELESS TELEGRAPHY.*

BY WILLIS H. JONES.

MARCONI'S system of wireless telegraphy finds its value in the application of the knowledge that an electrical discharge in the vicinity of iron filings will enormously decrease the ohmic resistance of the filings; that this decreased resistance will prevail as long as the resulting wave disturbance is maintained, and that the filings will resume their former abnormally high resistance upon slightly tapping or jarring the vessel in which they are contained. This means that an electrical wave will enable us to alternately place a high and a low resistance in a local circuit containing an ordinary relay and sounder, without actually removing or substituting any portion of the wire connections. If a tube of iron filings is made to form a part of the circuit which contains the relay, the latter will remain open when the high resistance obtains, because the current flowing will not be strong enough to magnetize the iron core. But when the incoming wave reduces the resistance by setting the small particles of iron filings closely together in regular order, the resulting increment of current sufficiently energizes the magnet to attract the armature, thereby closing the relay. The relay is, therefore, actuated very much after the manner of a neutral quadruplex relay; viz., by an increment of current.

It follows, then, that the Morse alphabet may be recorded on the relay by regulating the duration of length of the wave-making discharge at a distant point so that it will correspond with a dot or a dash. The mechanical construction of the receiving instrument, which is very simple indeed, is shown in the lower portion of the accompanying cut, while the sending apparatus is merely a large induction coil with a key in the primary circuit. The receiver, or coherer, as it is called, consists of a glass tube partially filled with iron filings. Two copper wires, *A* and *B*, are inserted in the tube from opposite ends and make metallic contact with the filings.

The local battery, *L B*, it will be seen, is short-circuited through the filings *via* the two wires *A* and *B*. The filings, therefore, form a part of the loop connecting the Morse relay. Now the small particles of iron within the tube, when arranged in the irregular manner in which they settle when promiscuously poured into the receptacle, introduce so much resistance into the circuit that what little current does circulate in the loop is insufficient to close the relay. But when the waves of ether from a distant point reach the sympathetically attuned metallic plates *W* and *W*[1], they impinge upon the plates, which action causes each separate particle of the filings in the tube to arrange itself in a regular position that shall be uniform with all other particles. The effect of this rearrangement of position is to enormously decrease the resistance* between *A* and *B*. As the remainder of the metallic circuit contains comparatively little resistance, the total obstruction to the energy of the battery is too small to prevent the current from closing the relay, hence the signal will be recorded on a sounder (not shown in the diagram) in the usual way.



After the signal has been made, that is, after the filings have been set in the regular order described, the Morse relay would remain permanently closed unless some means were devised for opening it preparatory to other incoming waves. Fortunately, a slight tap or jar of the tube will instantly destroy the uniform arrangement of the filings and again restore the high resistance between *A* and *B*. This high resistance will, of course, again decrease the strength of the current in the metallic circuit and practically demagnetize the relay, which immediately opens. In the lower portion of the diagram, the manner in which this end is attained is shown: *M* is an ordinary vibratory magnet or buzzer

---

*From *The Telegraph Age*, Vol. XXII, No. 4, page 67.

*In 1899 *Science Abstracts* No. 106, is given a digest of a paper by E. Dorn, on materials for coherers, appearing in *Wied. Annalen*, and which states that the noble metals—platinum, gold, and silver—give practically no coherer action. Iron gives good results, especially after a short exposure to air. Copper, immediately after filing, shows no change of resistance. After five hours a slight coherer action is observed, and in three weeks the resistance may rise to 300,000 ohms, which falls to 10 ohms under the influence of electric radiation, and rises to 187,000 ohms on concussion. Neither exhaustion nor heating have any influence on a tube containing aluminum filings. In tubes containing nickel, iron, copper or zinc, heating leads to a diminution of the resistance, which in zinc is probably due to sublimation.—ED.

controlled by the contact points of the relay *R*. A little hammer is attached to the armature of the buzzer in such a position that each down stroke of the armature of the buzzer causes the hammer to strike the glass tube a fraction of a second after the contact points of the relay close.

To summarize, wireless telegraphy is attained:

1. By setting ether in motion by means of the disruptive spark of the induction coil.
2. By catching the resultant waves of ether, which possess certain frequency or rapidity of motion, by means of a metallic plate sympathetically attuned to receive them and no others.
3. By reducing and restoring the high resistance of the iron filings in the coherer.
4. By regulating the duration of the wave impulses to correspond with the length of the Morse alphabet by means of a key in the primary circuit of an induction coil.

MOTOR-GENERATORS VS. GRAVITY BATTERIES.

MOTOR-DYNAMOS and dynamotors have become of great importance for furnishing all kinds of electric currents, without other generating machinery, in places where electric light circuits or other ordinary sources of electric power are available, their compactness and high efficiency making it practicable to use electric currents for a great variety of purposes, heretofore thought to be out of reach. The various applications already made are constantly suggesting new uses. The simplicity of an electrically-driven dynamo over one driven by belting has brought motor-dynamos into extensive use, even where shafting was available, while their economy in cost and space occupied, as well as their advantage in cleanliness when displacing chemical batteries for the operation of telegraph lines and for other work, is enormous.

The smallest size of dynamotor, occupying a space of about eight inches cube and having an output of $\frac{1}{12}$ horsepower, will displace about 800 cells of bluestone battery occupying a space of about ten feet cube. The Western Union Telegraph Company's estimate of $1.00 per cell per year as the cost of maintenance, exclusive of rent, makes the annual cost of operation $800 for a battery equivalent to the smallest commercial size of dynamotor, while this machine, which uses only the current required for two incandescent lamps costing less than two cents an hour, requires an annual expense of but $150.

WIRELESS TELEGRAPHY AS IT IS.

THE present status to which wireless telegraphy has been developed on the Marconi system, which is the only system, by the way, that has met with any success on a commercial scale, is given in the following interesting letter from Prof. J. A. Fleming, written in London on April 7th, of the present year:

"During the last few days I have been permitted to make a close examination of the apparatus and methods being employed by Signor Marconi in his remarkable telegraphic experiments between South Foreland and Boulogne, and at the South Foreland lighthouse have been allowed by the inventor to make experiments and transmit messages from the station there established, both to France and to the lightship on the Goodwin Sands, which is equipped for sending and receiving ether wave signals. Throughout the period of my visit messages, signals, congratulations and jokes were freely exchanged between the operators sitting on either side of the Channel, and automatically printed down in telegraphic code signals on the ordinary paper slip at the rate of 12 to 18 words a minute. Not once was there the slighest difficulty or delay in obtaining an instant reply to a signal sent. No familiarity with the subject removes the feeling of vague wonder with which one sees a telegraphic instrument merely connected with a length of 150 feet of copper wire run up the side of a flagstaff begin to draw its message out of space and print down in dot and dash on the paper tape the intelligence ferried across 30 miles of water by the mysterious ether.

"I cannot help thinking that the time has arrived for a more generous appreciation by his scientific contemporaries of the fact that Signor Marconi has, by minute attention to detail, and by the important addition of the long vertical air wire, translated one method of space telegraphy out of the region of uncertain delicate laboratory experiments, and placed it on the same footing as regards certainty of action and ease of manipulation, so far as present results show, as any of the other methods of electric communication employing a continuous wire between the two places. This is no small achievement. The apparatus, moreover, is ridiculously simple and not costly. With the exception of the flagstaff and 150 feet of vertical wire at each end, he can place on a small kitchen table the appliances, costing not more than £100 in all, for communicating across 30 or even 100 miles of channel. With the same simple means he has placed a lightship on the Goodwins in instant communication, day and night, with the South Foreland lighthouse. A touch on a key on board the lightship suffices to ring an electric bell in the room at South Foreland, 12 miles away, with the same ease and certainty with which one can summon the servant to one's bedroom at a hotel. An attendant now sleeps hard by the instruments at South Foreland. If at any moment he is awakened by the bell rung from the lightship, he is able to ring up in return the Ramsgate lifeboat, and, if need be, direct it to the spot where its services are required, within a few seconds of the arrival of the call for help. In the presence of the enormous practical importance of this feat alone, and of the certainty with which communication can now be established between ship and shore without costly cable or wire, the scientific criticisms which have been launched by other inventors against Signor Marconi's methods have failed altogether in their appreciation of the practical significance of the results he has brought about.

"The public, however, are not in the least interested in learning the exact meed of merit to be apportioned to various investigators in the upbuilding of this result. They do, however, want to know whether the new method of communication across the Channel, established by the expenditure of a few hundred pounds, will take the place to any considerable extent of submarine cables which have cost thousands of pounds to lay and equip. They do also desire to learn what reasons, if any, will prevent every lighthouse around our coasts from being forthwith furnished with the necessary apparatus for placing it in instantaneous and secure connection with the mainland. They also hope to hear that the methods can be applied to enable ships to be able in addition to communicate instantly in case of need with shore stations. To understand how far these things can be done, and to appreciate the necessary or present limitations of the method, it is requisite to explain that each vertical wire or rod connected to a Marconi receiving or sending apparatus has a certain "sphere of influence." Signor Marconi has proved by experiment up to certain limits that the distance to which effective signaling extends, varies as the square of the height of the rod. A wire 20 feet high carries the effective signal one mile, 40 feet high four miles, 80 feet sixteen miles, and so on. Up to the present time he has not discovered any method of shielding any particular rod so as to render it responsive only to signals coming from one station and not from all others within its sphere of influence. In spite, however, of what has been said, there is no inherent impossibility in attaining this desired result. At present all signals sent from South Foreland to France affect the receiver on board the Goodwin lightship. But this offers no difficulty. In an ordinary electric bell system in a hotel, the servant recognizes the room from which the signal comes by means of a simple apparatus called an indicator, and a very similar arrangement can be applied to distinguish the origin of an ether wave signal when several instruments are at work in a common region. Subsequent inventions, as also perhaps the promulgation of some necessary Board of Trade regulations for the use of the ether, will prevent official ether wave receivers from being disturbed by vagrant electric waves sent out by unauthorized persons in their neighborhood. The practical upshot, however, of the matter is that at present if more than two stations are not established within certain regions, these stations, pair and pair, can communicate with each other freely and regularly by means of ether wave signals sent out and received by long vertical rods or wires. No state of the atmosphere, and neither darkness nor storm, interrupts, so far as yet found, the freedom of communication.

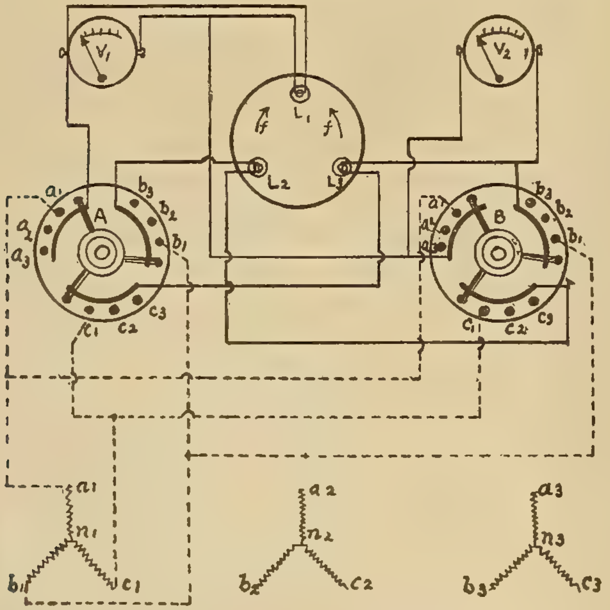
"Up to the present time none of the other systems of wireless telegraphy employing electric or magnetic agencies have been able to accomplish the same results over equal distances. Without denying that much remains yet to be attained, or that the same may not be effected in other ways, it is impossible for any one to witness the South Foreland and Boulogne experiments without coming to the conclusion that neither captious criticism nor official lethargy should stand in the way of additional opportunities being afforded for a further extension of practical experiments. Wireless telegraphy will not take the place of telegraphy with wires. Each has a special field of operations of its own, but the public have a right to ask that the fullest advantage shall be taken of that particular service which ether wave telegraphy can now render in promoting the greater safety of those at sea."

Generation

THREE-PHASE SYNCHRONIZING METHODS.

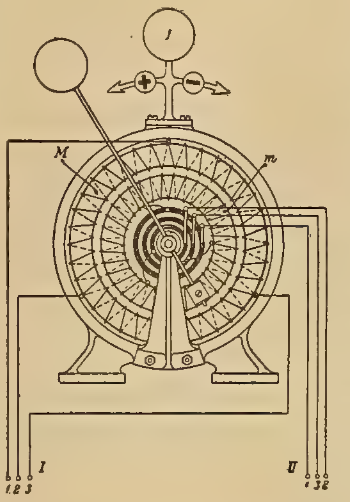
THE method adopted by the Siemens & Halske Electric Company for synchronizing three-phase generators possesses the advantage that if the machines are not running synchonously, the extinction of the lamps, which are arranged in a triangle, will travel around the triangle in one direction or the other according to whether the incoming generator is running below or above the speed of synchronism, thus indicating at once whether it is necessary to increase or diminish the speed of the incoming machine.

In the accompanying figure, *A* and *B* are two switches, each provided with as many arms (3) as there are generators, and a corresponding number of contacts. Corresponding terminals of the generators and switch contacts are indicated by the same letters. By means of the switch *B*, the terminals of any incoming machine may be connected to the 'bus bars through the synchronizing lamps L_1, L_2 and L_3. If the connections of the switch contacts were symmetrical, then the three lamps would at any instant be raised to the same incandescence. It will be noticed, however, that the connections are not symmetrical, the long segment contact corresponding to b_1, b_2, b_3, in switch *A* being in connection with the segment corresponding to c_1, c_2, c_3 in switch *B*. The result is that when the *a* circuits of two machines happen to be in phase, so that—with the switches *A* and *B* in their proper positions—the lamp L_1 is extinguished, the *b* circuit of one machine is connected to the *c* circuit of the other, and *vice versa*, the lamps L_2 and L_3 being raised to incandescence. The main switch is closed at the instant when L_1 is dark, and when the rate at which the extinction travels around the triangle shows the machines are running very nearly in synchronism. The voltmeters V_1 and V_2 are provided for greater sensitiveness.



SYNCHRONIZING THREE-PHASERS BY THE SIEMENS-HALSKE METHOD.

The Mueller method of synchronizing three-phasers not only shows whether two alternators are in phase, but also whether the unloaded machine, which is to be thrown in parallel with the other, is running too rapidly or too slowly. In this result it is similar to the Siemens-Halske method, but it is accomplished by entirely different means. In the adjoining figure the outside magnet *M* is stationary and the windings are connected to the 'bus bars, while the second or interior magnet *m* is capable of rotating and is in circuit with the alternator which is to be brought into phase with the currents in the 'bus bars. The connections are so made that the two rotating fields which are produced will revolve in the same direction, and there will then be no rotation of the movable part when the frequencies of the two currents are the same; but a torque will be produced when the frequencies are different and the rotation will then be in the same or the opposite direction to that of the induced fields, according as the frequency of alternator No. II is smaller than that of alternator No. I. A pointer with a signal dial is screwed to the movable part as shown; a deflection to the right or negative direction means that the speed of the alternator is too slow, and to the other side too fast. The mechanical power developed by this apparatus is quite great and it can therefore also be used for operating a regulator.



In a simpler and more effective modification of the Mueller method, there are two such fields revolving in opposite directions over stationary cores, both of which act on a third ring magnet, also stationary, which operates the signal; the latter is accomplished by means of a row of incandescent lamps, connected to this ring winding, and which will then be illuminated in succession so as to give the appearance of a wave of light moving in one or the other direction around a circle. When the two frequencies are the same this wave of light will appear to stand still, but when the speeds are different the movement of the wave of light will show whether the frequency of the machine to be connected is too high or too low, the speed of the rotation being an indication of the difference between the frequencies. Synchronism, in addition to equality of frequency, will exist only when certain special lamps are illuminated, and the machines must therefore be coupled only when the slowly moving wave of light appears over those lamps; this position may be indicated by an additional colored lamp. The apparatus may be simplified by winding both coils on the same core, the incandescent lamps being connected to a winding on a separate core; or, it may also be possible to have all three windings on a single core.

Roughly speaking, the generating capacity of a dynamo increases in proportion with the cube of the linear dimensions, while its radiating surface increases only in proportion with the square.

The *Canadian Electrical News*, of Toronto, characterizes the recent articles in the JOURNAL on the Kootenay-Rossland transmission, as being "a very complete description."

Industrial

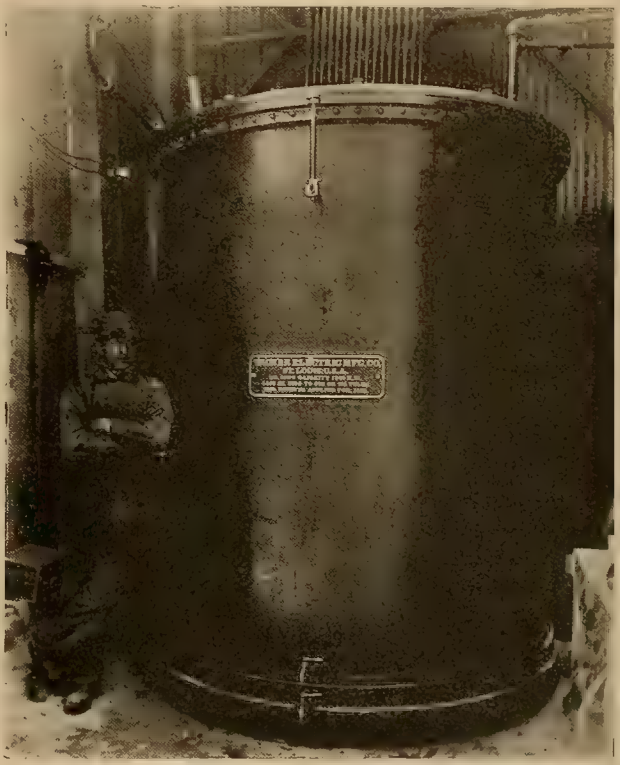
In responding to advertisements in this publication kindly mention "The Journal of Electricity, Power and Gas."

SEVEN 2000-HORSEPOWER TRANSFORMERS.

THERE are many interesting electrical installations at Niagara Falls in the plants of the great manufactories that have been located there by reason of the cheapness of electrical power derived from a generating station of the world-famous Niagara Falls electric plant. Of all these installations, that of the Union Carbide Company is most important in volume of electric energy consumed in its manufacturing processes. When the facilities of these works are fully developed, there will be in practically constant use not far from 25,000 electrical horsepower, the entire output of five of the great generators in the central station of the Niagara Falls Power Company. Such an enormous consumption of power has led to radical departures on the part of the electrical manufacturing companies from standards heretofore maintained for apparatus of the character called for in this work. To meet the requirements of this service most efficiently and with the least likelihood of interruption of service, very large units were called for. The design of these units has taken the engineers of electrical manufacturing companies into new realms, with the result that the eyes of the engineering world are centered on the apparatus that has been installed to meet the requirements here arising. It has, therefore, proven a matter of great surprise, as well as keen interest in manufacturing circles, that contracts for this installation should have been awarded a company not heretofore favored with any of the great orders that have been placed for machinery in the various Niagara Falls installations. Such action on the part of the Union Carbide Company is recognition of the success that has been achieved by the contractors in this instance in the design and manufacture of the particular form of apparatus called for in this installation.

In the manufacture of calcium carbide, a product, by the way, the consumption of which has assumed tremendous proportions, the electric current is an essential element of the manufacturing system. Indeed, calcium carbide is formed as a result of chemical action taking place when the fundamental elements of the carbide are introduced into the electric arc. All electric current used by the carbide company is transmitted from the great generating station of the Niagara Power Company at a high electrical pressure. Before it can be applied in the carbide furnaces, this electric current must be reduced in pressure to 110 volts. The transformers, as they are termed, which accomplish this reduction of pressure, constitute the apparatus which is attracting so much engineering interest. Heretofore the largest static transformers in practical service have been single-current of 1200 horsepower output. This transformer was considered an enormous one and at the time of its manufacture created great interest. The new units, however, which the carbide company has installed are of 2000 horsepower output each, and are seven in number. Nothing of the kind has been heretofore heard of in either foreign or American engineering practice. Much skepticism was expressed as to the ability of the company securing the contract to accomplish the results guaranteed. One well-known foreign engineer who has followed American practice very closely and been greatly interested therein, even went so far as to say that the temerity of the manufacturers astounded him. Every claim of the builders, however, and every argument advanced by them in advocating the construction of such large units, has been verified by the complete success of the apparatus so far delivered and installed.

The first of these great units was installed about four months ago and has been carrying continuously since that time its full load with most eminently satisfactory results in all respects. On this page is given an illustration of this apparatus as it appears in actual service. In outward appearance it is nothing more than a great iron shell. Inside, however, is the transformer proper, made up of tremendous windings of pure copper, grouped so as to accomplish the results desired. Surrounding these great copper windings is a large endless copper cooling coil through which a constant stream of running water is passing. This cooling coil, together with the transformer proper, is completely immersed in oil. This oil circulates freely through the windings of the transformer and carries away by both conduction and convection the heat losses arising in the transformer. This heat reaches the cooling coil by the circulation of the oil and is transferred to the running water in the cooling coil and thus carried out of the transformer entirely. Each of these units has the enormous weight of 40,000 pounds in complete form. As one stands beside the apparatus, it seems incomprehensible that so silent an agent should be performing work of such tremendous magnitude. The builders of this apparatus are the Wagner Electric Manufacturing Company of St. Louis, a company which has now attained a world-wide reputation for the manufacture of this form of electrical machinery, and also several other lines of apparatus largely used in the alternating-current field. This progressive company of the West entered the lists against the two great companies of the East who have heretofore monopolized the business at Niagara, and in successfully carrying out their contract, have set a pace in the electrical industry which means an immediate innovation of new ideas the world over in this particular form of electrical machinery.


THE LARGEST TRANSFORMER IN THE WORLD.

To the Wagner company is now due the credit of having not only built the largest units ever constructed in static transformers, but also the praise for introducing the highest voltage transformers in large units that have ever been placed in practical service. The latter apparatus installed on the circuits of the Telluride Power Transmission Company at Provo, Utah, have been most successfully operated about two years on a line pressure of 40,000 volts. The units in this service are of 300 and less kilowatt capacity each.

The development of the Wagner Electric Manufacturing Company has been one of the marvels of this electrical era. Seven years ago this company was organized with a capital stock of

$25,000 to manufacture one or two small electrical specialties. St. Louis, as a manufacturing center, and the rapid opening up of the electrical field, resulted in an expansion of this company into one with a very large capitalization, until now the industry ranks as the leading one of the West in its particular electrical lines. The company has branched out until its output is now being shipped to all parts of the world, and wherever it is sent is recognized for its excellence. Indeed, the aim of this company has been to build nothing but high-grade apparatus and the present influential position occupied by it in the electrical field is entirely the result of this broad gage policy. The company does not pretend to go into all fields of electrical machinery, but confines itself strictly to a number of lines of product of which static transformers head the list, with a new form of single-phase, alternating-current motor, indicating switchboard instruments, direct-coupled ventilating fans, storage battery charging outfits, switchboard work and direct-current motors and dynamos, constituting the other chief products.

An immediate consequence of the success achieved in the equipment of the plant of the Union Carbide Company at Niagara Falls has been to award the Wagner company the contract for the similar equipment of the great Canadian carbide plant now building at Ottawa, Canada, in which will be installed at the start twenty units of 150-kilowatt output each.

THE LOCKE PATENT SUSTAINED.

THE public will be interested in learning that the controversy over the inventorship of what is known as the Locke insulator, manufactured by Fred M. Locke, of Victor, N. Y., and comprising two or more shells of porcelain nested together and fused together with glaze, has been decided by the Examiner in the Patent Office to be the invention of Mr. Locke.

Mr. Locke filed his application for letters patent in February, 1897, and, in August of the same year, Mr. Boch, of R. Thomas & Sons Company, of East Liverpool, Ohio, filed an application for the same thing. An interference was declared between the two applications and also between Mr. Locke and a patent granted March 8, 1898, to Mr. Boch, which comprises substantially the same invention, except that the parts were fused together with extra glaze. Interference proceedings have been pending since September, 1897, and a couple of weeks ago the Patent Office decided that Mr. Locke had proved "that Locke was the first to conceive, disclose and reduce to practice the invention in issue; judgment of priority is awarded to Fred M. Locke."

And in the second interference with the patent of Mr. Boch the Examiner held that "whichever party is entitled to prevail as to the issue in one interference is equally entitled to prevail in the other; the fact in this instance, the burden of proof is upon Locke and that Boch is the patentee is of no moment, for to the Examiner's mind, Locke has established his claims of priority beyond a reasonable doubt. Judgment of priority of invention is awarded to Fred M. Locke."

Mr. Locke states that the patent in due time will be issued to him, and that all persons purchasing this class of insulators will be liable to him for damages and royalties for such use after the patents have issued.

NIAGARA FALLS PRINTS NEWSPAPERS.

RECENT additions to the power station of the Niagara Falls Power Company have enabled an increased supply of electricity to be utilized in the city of Buffalo, which lies twenty-six miles distant from the falls. The Westinghouse Electric and Manufacturing Company recently installed four 5000-horsepower generators in the power house of the Niagara Falls Power Company, doubling the original capacity, and have now under construction two more generators of the same size, which will increase the total to 50,000 horsepower.

The city of Buffalo is taking advantage of its proximity to this source of power, and every day applications to new industries are being made. The Great Northern Elevator and the Electric Elevator and others are exclusively operated by electrical motors equipped by the Westinghouse Electric and Manufacturing Company. This latter enterprising firm are now equipping the press-rooms of the *Buffalo Express*. This is the first newspaper of Buffalo to use the power of Niagara. By the end of the month it is expected that the installation will be completed, and the apparatus in good running order. Thenceforth every copy of the *Express* will be printed by power brought from Niagara, and the readers will be reminded in a visible and tangible form every morning of their proximity to this stupendous waterfall.

WAGNER COMPANY ITS OWN SALES AGENT.

The San Francisco office of the Wagner Electric Manufacturing Company desires the announcement made that the arrangement heretofore existing under which the California Electrical Works acted as selling agents of the Wagner company for California, Nevada and Arizona, has been annulled and that hereafter the business will be handled direct from the company's San Francisco office, No. 120 Sutter street.

TRADE LITERATURE.*

"Water Wheel and Steam Engine Governors." A general description of the Lombard Water Wheel Governor, together with reproductions of speed diagrams showing the degree of regulation which they have produced under various conditions in actual practice. The pamphlet is illustrated and contains letters showing satisfactory use in many prominent plants. 32 pages, 9x6 inches. *Lombard Water Wheel Governor Company*, 61 Hampshire street, (Roxbury District), Boston, Mass.

General Electric Bulletins. New bulletins were issued during August as follows: No. 4196, "Prices Paid for Street Arc Lighting in the United States;" No. 4197, "Automatic and Hand-Feed Electric Projecting Lamps;" No. 4198, "Thomson Astatic Instruments for Continuous-Current Switchboards;" No. 4194, "Magnetic Blow-Out Automatic Circuit Breakers for 500-volt, D-C. Circuits;" No. 4199, "Carbon-Feed Series Enclosed D-C. Arc Lamps;" No. 4202, "Type I S, A-C. Induction Motors for Single-Phase, 60-cycle, 104 to 115 volt circuits." *General Electric Co.*

Literature.

THE STEAM ENGINE INDICATOR, by F. R. Low. Size, 5½x9 in., 208 pages, 114 figures and 10 tables. Published by the Power Publishing Company, World Building, New York. Price, $1.50.

This work consists of directions for the selection, care and use of the steam engine indicator and the analysis and computation of the diagrams therefrom. It is compiled from the regular issues of *Power*, with revisions and extensions comprising numerous tables.

A book of this sort, appearing under the auspices, one might say, of such a publication as is *Power*, and from the pen of such an authoritative writer as is F. R. Low, its editor, calls for no criticism — it is above criticism. *Power* is too strongly intrenched in the minds of the steam engineering fraternity of the world to require introduction thereto, and the character of its invaluable articles is by far too well known to be elaborated upon. What, then, is to be expected when a line of these articles has been gone over with, redigested, rearranged, partly rewritten and supplemented by much additional matter and such tables as are necessary to render the subject matter full and complete? All steam engineers will know what to expect, and as the work is to and for them, the bare announcement of the appearance of the publication tells all there is to be said concerning it.

It may be added for others, however, that the book is a thoroughly practical, simple and exhaustive treatment of the methods of using, and of profiting by the use of, the instrument that is above all others, the key to the attainment of highest possible efficiencies in steam engine building and operation.

---

*Catalogues mentioned in this department will be mailed gratuitously on application to the concerns publishing them. When writing, mention THE JOURNAL OF ELECTRICITY, POWER AND GAS. Where addresses are not given, they may be found through reference to the Advertisers' Index on page iii.

THE JOURNAL OF
ELECTRICITY, POWER AND GAS.

VOLUME VIII. SAN FRANCISCO, NOVEMBER, 1899. NUMBER 5.

The Disposition of Three-Phase Transmission Lines.

BY AUG. J. BOWIE, JR.

IN alternating systems, the proper arrangement on the poles of the wires relatively to each other, becomes a matter of great importance in many cases. If the wires are badly arranged it may lead to serious interference with the regulation of the systems: raising the pressure in some circuits and dropping it in others, far out of proportion to the loads which they have to carry. The common remedy is to start in spiraling the wires, and usually it is regarded that the more spirals put into the lines, the better is the system arranged. This very often leads to the extreme, and many more spirals than necessary are used. Spiraling is a thing which should be avoided as much as possible, since it not only introduces complications into the system, but also is more or less a source of danger in transmission lines, where, if poles are not double armed at the spirals, the burning off of a single pin will let the wires come together, thus short-circuiting the line.

The idea of spiraling is to obtain (1) equal induction in any circuit; (2) no mutual inductance between circuits.

In transmission lines in order to obtain equal induction between the wires of a three-phase system, the wires are usually arranged on an equilateral triangle. In this event spiraling would be necessary only in order to avoid mutual inductance of the circuits, since the wires are so placed that, with a balanced load, the drop is equal in all. However, it is not necessary to arrange the wires on a triangle, but they can be placed on the same cross-arm and spiraled so as to have just the same effect. In case two circuits are run on a pole line the advantage of the latter arrangement is the saving of the additional cross-arms, and hence also there is a gain in height of the wires above the ground. The disadvantage is that the effective distance between the wires as regards inductance is increased to about five-fourths of its value in the preceding case, for a given minimum distance between wires, and, in case this distance is large, it will require very long cross-arms.

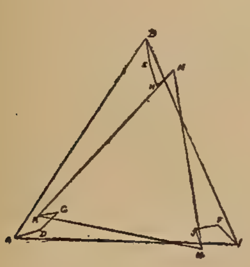


FIGURE 1.

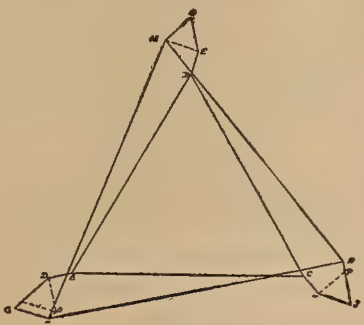


FIGURE 2.

In distribution lines, it is very often inconvenient to place the wires in the form of a triangle, and hence it is important to know how great the effect of unequal inductance will be, so as to know whether it is worth while to spiral the lines.

First take up the general case, supposing that the voltage triangle at the start is known, and that the currents and their phase relation are also known. The inductive effect on the A leg will be proportional to the number of lines of force which B causes to pass between A and B, plus the number of lines of force which C causes to pass between A and C—the sum being the vector sum.

This follows, since this is equal and opposite to the sum of the unbalanced lines of force cutting A; the vector sum of the currents in B and C being equal and opposite to the current in A. In this way it is easy to make either a graphical or an analytical solution of the problem.

All that is necessary is first to draw the voltage triangle. Next lay off a line from each of the vertices, representing in phase and magnitude the IR component of that particular wire. Next lay off, as mentioned, from the end of each such line, and 90° in phase behind each of the other currents, the inductive effect on the leg in question.* This inductive effect is equal to the reactance of a circuit of one-half the length of the circuit in question, multiplied by the appropriate current. In this way, the potential of the receiving end relatively to the transmitting end, is determined for each wire, and by joining the three points thus found we have the voltage triangle received.

Let $A\ B\ C$ be the order of rotation of the phases. In the general case, suppose the wires are any distance apart, no matter how irregularly spaced, and let the values of the three currents and their phase position be known. Let $A\ B\ C$ (Figure 1) be the voltage triangle at the station. Let the the problem be to find the voltage triangle at the place where the line or feeder ends. Call the resistances of the lines R_a R_b R_c and the reactances of the circuits $2L_{ab}$ $2L_{bc}$ and $2L_{ac}$ respectively. Let the currents be I_a I_b and I_c respectively. Lay off AD in phase with I_a and equal to I_aR_a. Similarly, BE equals R_bI_b and CF equals R_cI_c—being laid off in phase with their respective currents. Next draw $DG = I_cL_{ac}$ 90° behind CF. Then draw $GK = I_bL_{ab}$ 90° behind BE. Then K represents the position of the voltage of the end of the A feeder. Similarly, points M and N may be found for B and C. Then KMN will be the required voltage triangle.

The special case where the load is balanced is of more interest than the general case. Let the voltage triangle, ABC (Figure 2), be delivered to the load, which is balanced, and has a lag angle at the receiving end of ϕ. Let the problem be to find what must be the voltage triangle delivered to the lines at the station in order to deliver the equilateral triangle, ABC, at the end of the line. Let the wires be placed on the same cross-arm, and let the center wire be equidistant from the two others. Suppose the wires are placed thus: A B C, B being the center wire, and let the order of rotation of the phases be $A\ B\ C$. Let R be the resistance of each wire, and let I be the current in each wire. Draw AD, CF, and BE, each of which is equal to RI, and each of which is drawn in its proper phase relation. Let the reactance of $AB = 2L_1 =$ the reactance of BC. Let the reactance of AC be

---

*The voltage consumed in overcoming the effect of induction is 90° ahead of the current causing it. As has been shown, this induction is due to currents equal and opposite to those flowing in the other legs. Hence lines drawn 90° behind the currents in the other legs represent in phase this voltage, which is referred to as the inductive effect.

$2L_2$. Draw $DG = L_2I$ 90 behind CF, and draw $GK = L_1I$ 90° behind BE. Then K is the position of the voltage of A at the station. Draw $FJ = L_1I$ 90° behind BE, and $JN = L_2I$ 90° behind AD. Draw $EH = L_1I$ 90° behind AD, and $HM = L_1I$ 90° behind CF. Then KMN is the voltage triangle which must be furnished by the station. Let $L_2 - L_1 = L^1$. Draw $KO = L^1I$ parallel to GD, and lay off $NP = L^1I$. Then OMP is an equilateral triangle, and is the voltage triangle which would have to be furnished by the station provided the wires were arranged on an equilateral triangle on the poles, with sides equal to the distance apart of A and B or B and C. It is evident that $DO = FP = EM = L_1I$, and that DO is perpendicular to DA, FP is perpendicular to CF, and EM is perpendicular to BE.

In order to find the algebraic expressions for the lengths of the sides of triangle KMN, resolve the components of these sides, along two directions at right angles to each other, and take the square root of the sum of the squares. Resolve for each side, along and perpendicular to a line which would lag $\phi°$ behind the corresponding side of triangle ABC. Let $AB = BC = AC = V$. Then:

1. $(KN)^2 = (V \text{ Cos } \phi + IR\sqrt{3})^2 + (\sqrt{3}\, L_2 I + V \text{ Sin } \phi)^2$

2. $(KM)^2 = (V \text{ Cos } \phi + IR\sqrt{3} + L^1I)^2 + (\sqrt{3}\, L_1 I + V \text{ Sin } \phi)^2$

3. $(MN)^2 = (V \text{ Cos } \phi + IR\sqrt{3} - L^1I)^2 + (\sqrt{3}\, L_1 I + V \text{ Sin } \phi)^2$

If the lag angle is zero (*i. e.:* for a non-inductive load), then these equations become:

4. $(KN)^2 = (V + IR\sqrt{3})^2 + 3L_2^2 I^2$

5. $(KM)^2 = (V + IR\sqrt{3} + L^1 I)^2 + 3L_1^2 I^2$

6. $MN = (V + IR\sqrt{3} - L^1I)^2 + 3L_1^2 I^2$

It is plain that of the two outside wires, the one which leads the center wire drops more than the one which lags behind it. Let d be the distance between A and B on the pole, and let r be the radius of each wire. Then if l = length of the circuit $L_1 = (2\pi f / 10^9)\ (2 \log_e d / r + \frac{1}{2})\, l$. $L_2 = (2\pi f / 10^9)\ (2 \log_e 2d / r + \frac{1}{2})\, l = (2\pi f / 10^9)\ (2 \log_e d / r + \frac{1}{2} + 2 \log_e 2)\, l$. Hence, $L_2 - L_1 = (2\pi f / 10^9)\, l\, 2 \log_e 2 = L^1$, and is independent of any quantities except frequency, f, and the length of the circuit. Hence L^1 may be written as equal to $m\ k\ f$, where k is a constant, m being the length of the circuit in miles. The value of k is 0014. From equations 1, 2 and 3, it follows that the effect of this arrangement of wires may be calculated just the same as for three-phase circuits, which are equidistant, provided the following changes are made:

1. KN is calculated as if the three wires were equidistant, $2d$.
2. KM is calculated as if the three wires were equidistant, d, the resistance of each wire being increased $L^1/\sqrt{3}$.
3. MN is calculated as if the three wires were equidistant, d, the resistance of each wire being decreased $L^1/\sqrt{3}$.

For a frequency of sixty cycles, $\frac{L^1}{m} / \sqrt{3} = .048$, being of course, a constant.

If the problem be to find what voltage triangle will be delivered when an equilateral voltage triangle is given to the line at the station, it can be solved in a similar manner.

Evidently the voltage received would not be an equilateral triangle, under these circumstances, with a balanced load. However, if the load consists to any extent of motors, the latter act as equalizers of voltage — the legs receiving the higher voltages, taking more current than those with lower voltages. This reacts on the lines and tends to make the voltage triangle received much more nearly an equilateral triangle than any calculations on the supposition of balanced loads would imply. It is well however, not to rely on motors for such purposes, since, aside from other considerations, the motors are not acting at best efficiency under the circumstances, some legs being loaded more than others. In some experiments made by the writer with eleven per cent. difference of voltage between two of the phases, there was as much as sixty per cent. difference in the current taken by different legs of a three-phase motor. Of course, this was an excessive difference of voltage, and nothing like it should occur in practice.

If the lines are spiraled, running for a third of the distance ABC, for the next third BCA, and for the last third CAB, then with a balanced load, and with the three voltages equal at either end of the line, it follows from the symmetry of the problem that the drops in each of the feeders must be alike. Thus from equations 1, 2 and 3 it is plain that the station voltage of each line must be

$$\sqrt{(V \text{ Cos } \phi + IR\sqrt{3})^2 + (\tfrac{2}{3}\sqrt{3}\, L_1 I + \tfrac{\sqrt{3}}{3} L_2 I + V \text{ Sin } \phi)^2}$$

In other words, that is equivalent to a three-phase line arranged on a triangle, where the reactance of each circuit of the triangle is $2(2L_1 + L_2) / 3 = 2L$

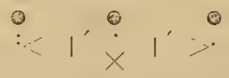
Hence $L = (3L_1 + L^1) / 3 = L_1 + L^1 / 3$

Now $L_1 = S.\ \log_e d / r + T$; S and T being constants when the length of the circuit and the frequency are fixed. Also $L^1 = S.\ \log_e 2$.

Therefore $L = S.\ \log_e d^1 / r + T$, where d^1 is the side of the desired triangle;

Hence $\log_e d^1 / r = \log_e d / r + (\log_e 2)\ \frac{1}{3}$

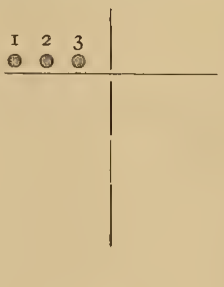
$(\log_e 2)\ \frac{1}{3} = .231 = \log_e 1.26$. Hence $d^1 = 1.26\, d$, or in other words, the effective distance apart of three wires, when arranged equidistant in a line and spiraled, is equal to 1.26 times the distance apart of the two nearest wires. For instance, if the wires are arranged thus



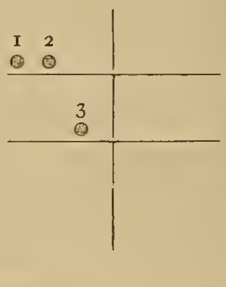
and spiraled, the inductive loss is just the same as if they were arranged on an equilateral triangle 1.26′ on a side. Of course the inductive drop would not increase in any such ratio. For example, the reactance of a circuit of No. 1 wire per mile of circuit at 60 cycles, with the wires 1′ apart, is 1.130, and the reactance of a similar circuit 1.26′ apart, is 1.185 — an increase of only five per cent. In fact, in the case of transmission lines, this will vary from about four per cent. to six per cent. Assuming ten per cent. IR drop, and ten per cent. reactance drop, as representing the average case for fully loaded transmission lines, this will increase the reactance drop only one-half of one per cent., and hence is not of any great importance.

It is possible in transmission lines to spiral three wires arranged on one cross-arm by the use of only one pole with two cross-arms, though a much better plan is to use two poles with two arms each in the manner shown below:

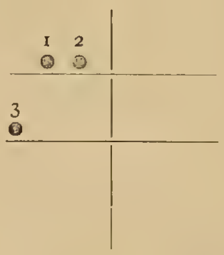
I



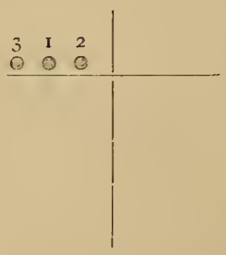
II



III

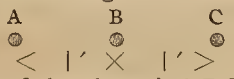


IV



Where it is only a question of avoiding unequal self-induction and not of avoiding mutual induction, the wires may be spiraled thus: 1 2 3, 1 3 2, 3 1 2. In other words, letting each wire occupy the center position for one-third of the distance. For, obviously, it makes no difference whether the wires are run 1 2 3 or 3 2 1, one arrangement being the same as the other looked at upside down. This is a point which may be made use of in distributing lines, since it is necessary to cut only two of the wires and not all three at each spiral.

To see how great will be the effects of unequal self-induction caused by not spiraling the wires, four examples have been calculated. In each case the supposition is made that an equilateral voltage triangle of 1000 volts on a leg, is delivered to a balanced load from the station which is a mile away. The frequency is 60 cycles, and the wires are arranged on a cross-arm one foot apart thus:



The order of rotation of the phases is A B C. In each case considered, the drop, $IR\sqrt{3} = 50$ volts.

Case 1. Non-inductive load, No. 0000 copper wire. 111 amperes per leg.

Case 2. Non-inductive load, No. 6 copper wire. 13.8 amperes per leg.

Case 3. Power factor .8, No. 0000 copper wire. 111 amperes per leg.

Case 4. Power factor .8, No. 6 copper wire. 13.8 amperes per leg.

Case 1. $I = 111$; $L_1 I\sqrt{3} = 97.8$; $L_2 I\sqrt{3} = 113.5$; $L^1 I = 9.3$; $KN = 1056$; $KM = 1064$; $MN = 1045$; and the drops are 5.6 per cent., 6.4 per cent. and 4.5 per cent.

Case 2. $I = 13.8$; $L_1 = .633$; $L_2 = .72$; $IL^1 = 1.2$; $KN = 1050$; $KM = 1051$; $MN = 1049$; and the drops are 5.0 per cent., 5.1 per cent. and 4.9 per cent.

Case 3. $KN = 1110$; $KM = 1107$; $MN = 1093$; and the drops are 11.0 per cent., 10.7 per cent. and 9.3 per cent.

Case 4. $KN = 1050$; $KM = 1050$; $MN = 1048$; and the drops are 5.0 per cent., 5.0 per cent. and 4.8 per cent.

In the formula deduced, no account was taken of the effect of capacity of the lines. As a rule, only in very long lines run at very high pressures, will the capacity effect become of any importance as affecting the inequality of the three voltages. However, a three-phase circuit with three wires on the same arm, may be spiraled in the following way so as to overcome practically all inequality of voltage due to capacity or leakage:

Run *ABC* one-sixth of the way, then *BCA* one-sixth of the way, then *CAB* one-third of the way, *BCA* one-sixth of the way, and *ABC* the remaining one-sixth of the distance.

DESTRUCTION OF THE BLUE LAKES POWER PLANT.

About five o'clock A. M., on Wednesday, November 1st, the generating station of the Blue Lakes Water Company, at Blue Lakes City, near Mokelumne Hill, Cal., was entirely destroyed by fire.

The building consisted of a steel frame, covered with corrugated iron. The floors, switchboard platform and frame, the transformer gallery and office, were all wood. The 10,000-volt switchboard was close to the north wall with a 2000-volt board directly in front of it and about eight feet distant. All the transformers were located on a gallery which was supported by the north wall of the building on one side, the 2000-volt board on the other and which covered both boards completely, forming a roof over the space between them. This space was closed at the east end by the office but was open at the other end. The telephone room was located directly at the open end of the boards and in such a position that anyone coming out of the room would see anything going on in the space between them.

On the transformer gallery were three 500-kilowatt, oil-insulated, water-cooled Stanley transformers, two of which were connected to the Stockton circuit, the other being an idle transformer in reserve. These were all located at the east end of the gallery, the two live ones being over the office, and the dead one over and back of the end panel of the 2000-volt board. Besides the three transformers mentioned, there were six 75-kilowatt, air-cooled Stanley transformers connected to the Calaveras circuit, and four others of the same type and make connected to the Amador circuit. The floor and timbering of the gallery were extremely heavy, and additional shores of 6x6 Oregon pine were put in when the large transformers were installed last summer. The floor of the gallery was of tongue and groove pine laid in two layers. All the leads from the board came up from below through large holes in the floor, with no bushings, the air space being depended on for insulation. The whole floor was saturated with oil which had leaked from the transformer cases and from the barrels when the cases were originally filled, to such an extent that oil had dripped through. This leakage was taken care of by placing metal drip pans under the transformers. At the time of the fire these pans had not to exceed one-eighth of an inch of oil in them. The floor was practically free of clear oil, but the wood was saturated from previous leakage. The 25,000-volt board was located in the roof and was in no way involved in the fire until the building collapsed.

Inasmuch as there has been some discussion as to the kind and quality of oil used in the transformers, it may be well to go into some detail on this point. The oil was high grade and known to the trade as "Mineral Seal," 300° test, and was supplied by a responsible firm. A lighted match dipped in it would be extinguished at once. On one occasion, to satisfy one who had complained of the danger of using oil-cooled transformers, a handful of waste was thoroughly saturated in it, then set on fire, and when fully ablaze was immersed in the oil with the result that the fire was instantly extinguished. On two occasions, short circuits in the transformers failed to set fire to the oil, and in one of the instances the short circuit was maintained for nearly ten minutes. The oil was amber color by reflected and steel blue by transmitted light.

Two men were always on watch, a dynamo tender and a helper. Their orders were that in case of trouble the tender was to shut off the water and the helper was to notify the station foreman by telephone. Besides the routine duties of such a station, the tender was required to go on the gallery frequently, and be sure that the water was circulating properly in the cooling coils. He had done this not more than fifteen minutes before the trouble began, and both men were seated in front of the board when suddenly the machines slowed down and all the lights went out. While the tender was shutting off the water the helper ran to the telephone, rang the bell, and without waiting a reply ran back and pulled the three machine switches, and also shut the water off the third wheel. As he left the telephone room he saw burning material dropping down through the wire holes in the gallery floor, also a heavy arcing on the back of the 2000-volt board. Meantime the tender had shut the water off the two end wheels, and had pulled the Amador circuit switches. At this time both men noticed that the marble was cracking and beginning to fall. There was the sound of fierce fire with a great smoke coming from the neighborhood of the oil transformers, and fire was breaking out from the office. Both men then left the building and saved only that which they had on their backs. It must not be supposed that their accounts agree in detail, but they do agree as to the facts stated above.

In about twenty minutes to a half hour later one of the oil transformers fell through the floor, and was followed shortly after by the other two. This added about 2250 gallons of the oil to the flames, and in a little while the building collapsed under the intense heat.

The behavior of the lights on the different circuits is significant. In Stockton, the lamps flickered, went out for a moment, then came up again for one very brilliant flash and then went out to stay. On the Calaveras circuit the same course was observed. On the Amador circuit the same was noticed, except that the lamps did not relight after the first going out. In this connection it should be observed that the Amador circuit was pulled by the dynamo tender, and he stated he pulled this circuit, and only this one, before he knew there was any difference in the behavior of the three circuits. The most significant fact in this connection is that both phases were affected alike in every way. Both behaved alike, and the changes were simultaneous.

It is inconceivable that both the oil transformers could have failed at precisely the same instant, and yet this must have been the case if the oil transformers were in any way the cause of the fire. It is established beyond doubt that they did not short-circuit, since, as soon as they were cold enough to be handled, they were opened and every foot of wire was wound off from the original coils to a wire reel, in a rigid inspection in the presence of E. E. Stark for the Stanley Electric Manufacturing Company, and A. H. Babcock for the Standard Electric Company. In every coil the wire was continuous and uninjured, and nowhere was there the slightest evidence of a short circuit.

When this examination was concluded, a search was made for evidence of a sudden rush of oil from any of the cases. The only way for oil to get out of the cases was by a leak over the top, or by the breaking of the oil outlet pipe. All three of the outlet valves were found, and in every case the evidence was conclusive that the valves were properly closed. A further demonstration that oil did not leave the cases in quantity until they fell was noticed some days after the fire. An examination of the exterior of the cases showed that the water worm had kept cool the iron near it; in fact it was possible to trace the extent of the worm by the appearance of the outside of the case. The worms were not in contact with the case, hence the cooling action must be by conduction to be effective, rather than by radiation; in other words, there must have been a conducting medium inside the case for a considerable time, as well as a supply of water for the same time. Oil was the only medium within the case, and it is established that the water did not fail until the building fell, for it was then that the fire hose became useless through the breaking of the pipe. The three cases are intact and apparently tight as ever. The covers were all in place and uninjured except for a slight warping. It is safe to say that there was no explosion of oil within any of the transformers.

It is possible that the cause or origin of the fire will never be discovered. The evidence available at present indicates that it started on the 2000-volt board as a short circuit, and that the flame ran up to the leads to the oil-soaked floor of the gallery. Once there was fire there, the rest is easily understood.

Distribution

INDUCTION MOTORS.

BY R. F. MARKILL.

THE birth of the induction motor dates back for twenty years, when Walter Baily exhibited his polyphrase motor to the Physical Society of London on the 28th of June, 1879. This motor consisted of a series of poles, each of which was magnetized in turn by primary cells, thus imparting rotation to a copper disc suspended above them.

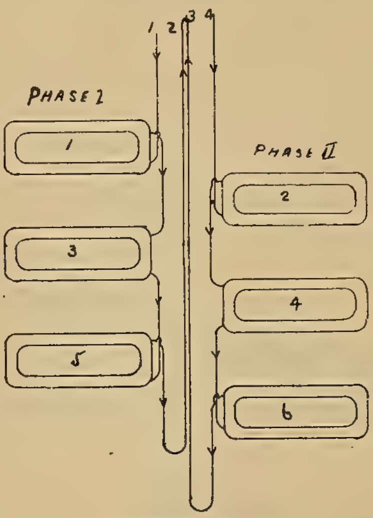
Marcel Deprez exhibited a motor in Paris in 1880 in which he artificially produced two-phase currents by means of a rotating commutator, the current being generated by a battery.

Professor Galileo Ferraris, of Turin, constructed a two-phase motor driven by two alternating currents which were caused to differ in phase by inserting an inductive resistance in one circuit and a non-inductive resistance in the other. A model of this was exhibited at the World's Fair, Chicago, in 1893.

Nicola Tesla worked along these lines between 1887 and 1891. From his early patents the principle of the action of induction motors is thus described: "A motor is employed, in which there are two or more independent circuits, through which alternating currents are passed at proper intervals, for the purpose of effecting a progressive shifting of the magnetism, or the lines of force, in accordance with the well known theory, and the consequent action of the motor.

A number of polyphase motors were exhibited at the Frankfort Exhibition in 1891, nearly all exhibitors being Germans. Messrs. Lehmer & Co. exhibited a model three-phase central station from which were driven a number of small three-phase motors and a 10 horse-power synchronous motor. In the well known transmission from Lauffen to Frankfort, a distance of one hundred and ten miles, a 110 horse-power three-phase motor was employed to pump water for a fountain. A small three-phase motor of 3 horse-power was also driven, having a revolving primary and a stationary secondary—the reverse of the present usual construction.

Professor Silvanus P. Thompson defines a field as "that part of a dynamo in which the magnetism is fixed, while the armature is that part in which the magnetism changes direction." In the induction motor the magnetism is fixed in direction in the rotating part, because as the pole moves the iron moves also, so that their positions remain the same relatively to each other, while in the stationary primary the magnetism reverses with the alternating current. Hence the stationary primary should be called the armature and the revolving secondary the field. This, however, is not followed in practice, the rotating part being called the armature. Thompson coins two words to overcome the difficulty, calling one the stator and the other the rotor, but we may also speak of them as simply primary and secondary.



THE INDUCTION MOTOR.

All alternating current machines are built up of sheets of laminated iron slightly insulated from each other to prevent flow of eddy currents, which have an injurious effect and cause great heating of the iron. C. E. L. Brown, of Zurich, experimented on different kinds of rotor windings and found the best to be a squirel-cage winding on a laminated iron cylinder. However, various kinds of windings are now used.

The action of the induction motor may be described as follows: When we throw the current on a two-phase induction motor, a magnetism is set up in poles 1 and 3 by phase one, and this is followed by another magnetism that is set up in poles 2 and 4 by phase two, at right angles to the first. This has the effect of a magnetic pole moving along from left to right. The magnetism sets up a current in the secondary winding, and, as it moves along, tends to drag the conductors with it, giving a rotating motion. In a single phase induction motor the magnetic poles do not move along or rotate in this lateral way, and the rotor has to be started by some external force after which it will continue to rotate. The single phase is like a single engine on its center, while the two-phase motor is like a compound engine with cranks at right angles.

When the motor is running, the secondary conductors cut the magnetic lines and tend to set up a current opposite to the induced current. This is due to an electromotive force similar to the counter electromotive force of a direct current motor, and chokes down the induced current. There is no such counter electromotive force to choke down the current while the motor is at rest and the switch is thrown in to start it, and hence a starting resistance is put in, this having the effect of bringing the current into phase with the electromotive force, as the resistance is large compared with the inductive resistance of the rotor. As the speed increases this is cut out. When the motor is running light and the speed is high the counter electromotive force brings the current down to a very small amount, but as the load is put on and the motor is slowed down the curent is proportionately increased. In order to connect in the starting resistance, collector rings and brushes on the rotor are necessary in some cases, but there are exceptions to this, as for example the Westinghouse Company uses an auto starter* which is in the primary and not any resistance in the rotor. This resistance may be metallic or liquid. Both are used by the Stanley Company, Krupp metal ribbon being used for the one and a solution of carbonate of soda for the other. This resistance is cut out gradually as the motor comes up to speed.

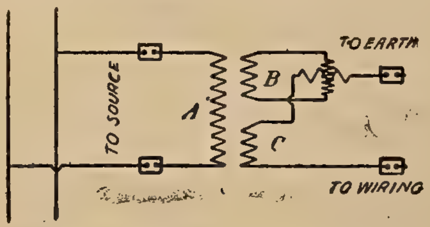
Two-phase motors usually have a separate winding on the rotor for each phase, the two windings being connected at one end and this point connected with the middle collector ring, the other two ends going to the outside collector ring—this being a case where an external resistance is used in the rotor. The field coils are generally wound on forms to fit the poles and connected in series on each half field, the poles on the two half fields being staggard, as the current in the two halves differs by 90 degrees. These two halves are connected directly to the secondary of the transformers or the line as the case may be. Some induction motors have copper "compensating segments," which are simply copper castings forming a closed secondary circuit around the poles. Their effect is to counteract the self-induction of the field coils, the action being similar to the short-circuiting of the secondary of a transformer. There being only one turn in the copper segments, the voltage is very small, but considerable current flows, causing these segments to become quite warm.

One of the great difficulties experienced in the use of induction motors is their effect on the line causing a large wattless current to flow, thus reducing the voltage and severely taxing the generators, and, furthermore, makes lighting very unsteady on the same circuit with motors. This can be somewhat overcome by the use of condensers, the action of which is to counteract self-induction, thus reducing the line current to a minimum and making it much easier to run lights and motors off the same circuit.

Operation

MEASURING INSULATION OF ALTERNATING CIRCUITS.

A DIRECT-READING ohm-meter for measuring the insulation resistance of alternating-current circuits is made by the General Electric Company of Berlin, and is due to Benischke. In Germany it is required that the insulation resistance of circuits be taken with the voltage for which they are intended to be used, and the Benischke ohm-meter was designed for use on moderate alternating voltages. The instrument is an electro-dynamometer and a transformer with circuit connections as shown in the adjoining diagram. The primary winding *A* of a small transformer is connected with the source of alternating current, the voltage of which is that at which the insulation of the wiring is to be measured. There are two secondary windings, the coil *B* being connected with the fixed coil in the electro-dynamometer, while the second one, *C*, is connected through the movable coil to the earth and the other pole to the wiring whose insulation is to be measured. The fixed coil will develop an alternating field of constant intensity; if a current passes through the movable coil the latter will be deflected, the reading being taken on a scale calibrated directly in ohms. The sensitiveness of the instrument may be increased by increasing the number of ampere turns in the stationary coil, which is easily done by means of the transformer shown. The coils *A* and *C* have the same number of windings in order that the voltage at which the insulation is tested is equal to that of the mains; as the readings of the scale are correct only when the voltage is the proper amount, it is necessary to know whether this is the case. This may be done by the same instrument, which also has a scale of volts and will read the voltage when the two right hand terminals in the figure are connected together. The sensitiveness is so great, that at 120 volts a deflection of one millimeter represents one million ohms; and three millimeters a half million. The instrument has a further advantage in that it is not injured when a new installation is tested in which there may be a dead ground, as in that case it will give the maximum deflection, which means zero resistance. With three-phase installations two readings are necessary in order to find the insulation in one of the three wires, and in installations having a neutral point, the insulation of the whole wiring can be measured by connecting the high tension winding of the transformer between the neutral point and the earth. Further details concerning this interesting instrument will be found in the *Electrotechnischer Zeitschrift*, Berlin, for June 8, 1899.



BREAKING HEAVY HIGH TENSION CIRCUITS.*

BY W. L. R. EMMET.

A GREAT deal of work has recently been done on circuit-opening devices for heavy duty. One of the principal troubles in such work is the difficulty of making experiments. We have a testing outfit at Mechanicville, with which we can get from 300 to 400 amperes at 15,000 volts with an inductive load, and at Niagara Falls I have tested some devices with 700 amperes and 13,000 volts and a highly inductive load, the voltage rising to 18,000 when the circuit was opened. In comparison with past experiences these conditions seem heavy, but they are light when compared to those which must be met in some plants that are now being installed.

There is, of course, a limit to the capacity of every circuit-opening device, and as power units become enlarged it will be necessary to provide means for limiting the total amount of power that can be delivered to individual branches; such reactances can be so proportioned that they do not materially interfere with the normal operating conditions, and, at the same time, they can so limit the total power delivered that it is kept within the safe range of the circuit-opening devices. Up to the present time such reactances have not been much used. Their introduction naturally somewhat affects voltages, and for this reason may be considered undesirable. By judicious arrangement and proportioning the objections can, to a great extent, be overcome, and there is little doubt that such devices will be much used in the future.

I have prepared sketches of a few circuit-opening devices that have resulted from recent investigations and experiments, and will briefly describe their design.

Figure 1 shows a fuse block in which the fuse is in a state of tension between two hinged terminals; these terminals are pulled apart by springs and receive current through flexible connections. The fuse is punched out of sheet metal, the narrowest portion being at the middle. It is placed between two blocks of porcelain, a small amount of clearance being provided where the fuse passes through, so that its ends can be freely withdrawn by the movable terminals after the narrow part of the fuse has become ruptured. Around the narrow part of the fuse the porcelain blocks are recessed so as to provide an air chamber; this chamber is vented by a hole in the upper block. The whole device is firmly clamped together, so that the only opening to the outer air is through this one vent-hole. The fuse, being under tension, does not quite reach the melting point before the break occurs. It loses its tensile strength at a low red heat and pulls apart. It is quickly withdrawn by the springs from the air chamber in which it has been broken. A very small amount of the metal is volatilized and its gas is blown out of the vent-hole. For the purpose of preventing any deposit of metal fumes on the porcelain surfaces, these surfaces are lined with muslin that has been treated with shellac or varnish and pressed into the desired shape. This lining covers the interior of the chamber in which the fuse is broken and the porcelain surfaces between which the fuse is drawn. These linings are supplied with the new fuses, and are renewed if any appreciable amount of burning has occurred.

---

*Described in general in the JOURNAL, Vol. VI, page 35, August, 1898. For its principles of operation see the JOURNAL, Vol. VI, page 100, November, 1898.

*Abstract of a paper read the National Electric Light Association, New York, May 23-25, 1899.

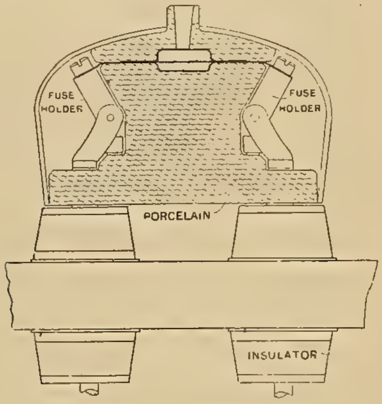


FIGURE 1.—TENSION FUSE.

With a fuse of this type, occupying a space of six inches by three inches on a switchboard, I have repeatedly broken 300 amperes at 13,000 volts without the slightest injury to the device.

Figure 2 illustrates the principle of a circuit-breaker that has produced excellent results. Two terminals are placed side by side on a vertical board, and are separated, both in front and behind the board, by high barriers. Into the metal surrounding these terminals stout fibre tubes are attached, which extend downward on either side of the barrier. Two copper rods, connected at the bottom by a crosshead, are inserted in these tubes, and forced upward until they make contact in the terminals; the circuit is thus established through the copper rods and the crosshead, around the lower extremity of the barrier, and through the fibre tubes. The crosshead carries a piston, and this piston moves in a long, air dash-pot. To set the circuit-breaker, the rods are forced upward, by means of a wooden rammer, until the contacts are made; in this position the rods are held by a latch, controlled by a solenoid. When the proper amount of current is put through this solenoid the latch is released; a spring starts the rods downward, so that the circuit is broken in both tubes; the gas produced by the arc expels the rods rapidly from the tubes, the acceleration being checked by the dash-pot. This device has been found very effective on the heavy circuits with which we have experimented. It occupies a small amount of space and is simple in its mechanical construction.

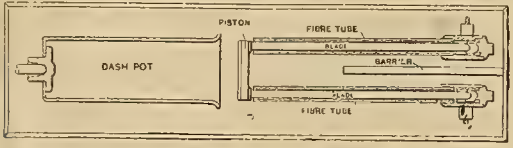


FIGURE 2.—PISTON FUSE.

Figure 3 illustrates the construction of a switch or circuit-breaker somewhat similar in principle to that shown in Figure 2. In this case the terminals are at the lower end and are situated inside of vessels into which the fibre tubes project for a short distance. These vessels are partly filled with oil, the break occurring below its surface. In the switches of this type which we have designed the rods have been withdrawn from the tubes by a pneumatic cylinder. The presence of the oil materially increases the breaking power of the switch, and reduces the violence of the explosive effect when the circuit is opened.

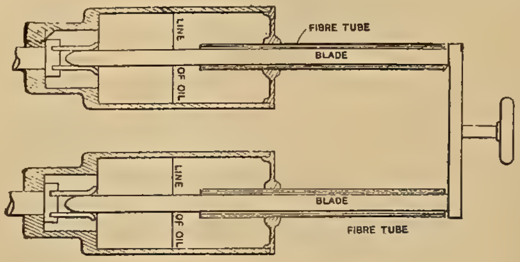


FIGURE 3.—OIL-BREAK FUSE.

Figure 4 shows a shunt-fuse device that has been used in connection with circuit-breakers at Niagara Falls and elsewhere. The object of the design is to produce a fuse that can be placed in shunt with the circuit-breaker, to open the circuit after the main contacts are broken. It is, of course, desirable so to design such fuses that they can be very easily replaced. The fuse is placed in a slot in a long, wooden rod; this wooden rod is covered by a paper tube, and part of the rod is cut away at three points so as to form air chambers inside of the paper tube. The rod is inserted in a long, wooden tube, provided with vents that come opposite to these air chambers, when the fuse is in place. The fuse is a small copper wire, and is attached to ferrules on the rod which make contact with springs at both ends of the tube. When the current is diverted into the fuse, which immediately volatilizes, the pressure in the chambers bursts the paper opposite the vents and the gas escapes through chimneys provided above the vents. The paper covering of the rod prevents the hot gas from getting into the interior of the tube; consequently the device can be used over and over again without any deterioration. These fuses have worked perfectly in parallel with circuit-breakers under the most difficult conditions that we heave yet been able to produce.

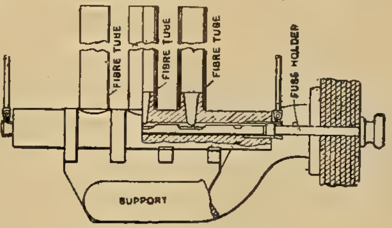
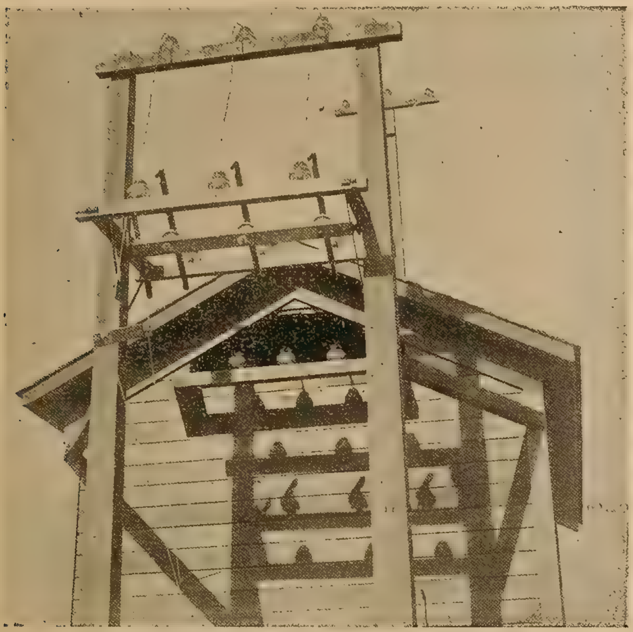


FIGURE 4.—SHUNT FUSE.

HIGH-TENSION SWITCHES AT BAKERSFIELD.

FOR nearly two years the Power Development Company, of Bakersfield, Cal., has been using a novel form of high tension switch and fuse combined with perfect satisfaction during all the kinds of weather peculiar to that portion of the State. The switch is used on all branch lines and at all pumping stations of the Kern County Land Company, the potentials handled by it varying between 10,000 and 11,000 volts. It is essentially an outdoor switch, is of the triple pole, double break type, and is used principally as a means of cutting out the secondary sub-stations for inspection and cleaning.

The features of the switch are so clearly shown in the accompanying views that detailed description is unnecessary. In general, it is erected in a frame supported by two poles just outside the station. Within the frame is pinioned a 4x4 timber carrying three arms, which in turn support the switch clips that, as well, form the terminals of a copper wire fuse twenty-eight inches in length. The switch is controlled by sash cords manipulated from within the station, and the double break as well as the mode by which ordinary line insulators are made to preserve insulation is clearly brought out in the illustrations.



THE WHORFF HIGH-TENSION SWITCH AS ERECTED.

It is only necessary to add that in refusing the switch, the tube is removed from the clips which support it on the arm of the switch; also, that the design of the switch and fuse is due to Frank T. Whorff, Superintendent of the Power Development Company at Bakersfield.

FARMING BY ELECTRIC POWER.

NOW that the pumping of water for irrigation purposes by electric power has become a well established field of usefulness for electrically transmitted power, it may be well for transmission companies supplying power to the great valleys of California to devote some attention to the development of an equally important field, namely, electric farming. In Germany, contracts are taken by electric companies for farming by electric power, including ploughing, harrowing, sowing and harvesting, while recently, according to a Canadian electrical exchange,* the Canadian Pacific Railway Company has tested the use of steam power for agricultural purposes at Morden, Manitoba, in which the engine moved at a speed of one and one-quarter miles per hour, and dragged after it a gang of ten plows, which turned over a width of twelve feet of earth of a depth of four inches. No information is given regarding the horse power of the engine, but it is stated that herbage cut on the prairie a few days previous was burned and that the machine was capable of plowing twenty acres daily, which, at the usual cost of $3.00 per acre, would seem to leave a margin for profit to a transmission company.

According to C. Pio, in *Elettricita*, of Milan (Vol. 18, pp. 117-120, 1899), the bridging of the pole pieces of rotary converters by copper plates to avoid pumping, occasions a loss of power of about 1.5 per cent.

---

* *Canadian Electrical News*, October 1899, page 216.

Personal

CLARENCE A. ROSS, manager of the Chicago office of the Sawyer-Man Electric Company, was a recent visitor to the Coast.

SIDNEY SPROUT has retired from the Rawhide mine to resume practice as consulting and constructing electrical engineer, with offices at 106 sixth floor, Crocker Building, San Francisco.

A. M. HUNT and **WYNN MEREDITH** have been appointed engineers for the mechanical, hydraulic and electrical installation of the proposed Truckee-Virginia transmission to the Comstock mines.

C. E. DUTCHER, chief electrician for the Comstock Pumping Association, has been appointed superintendent of construction for the Truckee River General Electric Company, with headquarters at Virginia City, Nev.

LEO DAFT, well known throughout the electrical world for his pioneering experiments in electric traction on the Ninth avenue elevated road in New York City in 1887, has returned to this country after a long trip through Australasia and the Orient.

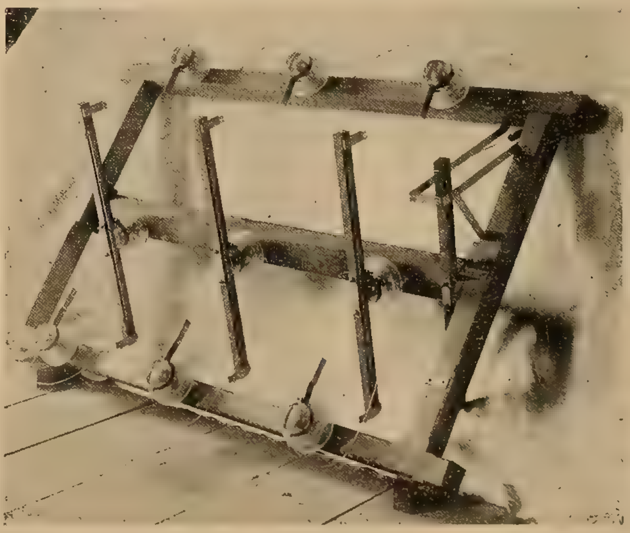
W. A. BURKHOLDER, having finished his contract for the building of the transmission lines for the Mount Whitney Power Company, has gone to Phillipsburg, Montana, to build a transmission plant for the Montana Water, Electric Power and Mining Company.

F. C. CROSBY, of the engineering corps of the Standard Underground Cable Company, Pittsburg, Pa., has arrived in San Francisco to take charge of the installation of the underground cable in the conduits of the Independent Electric Light and Power Company.

PHIL. S. TAYLOR has accepted the position of assistant to R. S. Masson, superintendent of the Independent Electric Light and Power Company, San Francisco, and he has, in consequence, resigned from the operation engineership of the San Gabriel Electric Company, Los Angeles.

E. E. STARK, B. S., formerly engineer for John Martin and the Pacific Coast agency of the Stanley Electric Manufacturing Company, and more recently managing engineer for the Ferrocaril Electrico Jalapa a Cordoba, Jalapa, Mexico, has returned to San Francisco in acceptance of his former position with Mr. Martin, vice T. E. Theberath, resigned, who has become engineer for the Yuba Electric Power Company.

"THE JOURNAL OF ELECTRICITY, POWER AND GAS is a very interesting periodical. The writer takes a good deal of pleasure in running through it thoroughly. There is much in it of engineering value," writes the general manager of one of the largest electrical manufacturing companies in a letter of recent date.



DETAILS OF THE WHORFF HIGH-TENSION SWITCH.

THE JOURNAL OF
ELECTRICITY, POWER AND GAS

Devoted to the Conversion, Transmission, and Distribution of Energy.

Conducted by GEO. P. LOW.

Official Organ of the Pacific Coast Electric Transmission Association.

Yearly subscription: Domestic, $1.00; Foreign, $1.50, postage paid.

Entered as second-class matter at the San Francisco Post Office, August 15, 1899.

Entered as *The Electrical Journal*, July, 1895. Entry changed to *The Journal of Electricity*, September, 1895.

Published monthly at 320 California Street, San Francisco, Cal.
Address remittances and communications to
315 CHERRY STREET, [Telephone, "Pine 76"] SAN FRANCISCO, CAL.

VOLUME VIII NOVEMBER, 1899 NUMBER 5

For Table of Contents see Page X.

EDITORIAL.

POLYPHASE TRACTION AGAIN.

The editorial appearing in these columns for August on "Polyphase Electric Traction" has brought about considerable discussion, and among the suggestions that have been received pertaining to the subject are two of especial merit. There are indeed many sides to the question presented, but in addition to the schemes detailed in the editorial referred to, Lieutenant W. Stuart Smith, U. S. N., points out that there is still another way of applying polyphase traction that under some circumstances is not to be overlooked. This new method would be practically limited to train service, and it contemplates power generated and transmitted as polyphase alternating current; step-down transformers located as required and feeding into a low-tension working circuit consisting of two overhead wires with rail for the third side, or of one overhead with rails and a third rail; rotary transformers carried on the train and delivering current to locomotive motors or distributed motors on the cars in multiple units as may be desired. The trains will thus become traveling rotary converter stations requiring no extra attendance, and as moderate size static transformers can be frequently located, the weight of overhead structure can be kept within reasonable limits.

Under some circumstances, as stated, this suggested method would be of undoubted value, and it seems that it would be of exceptional utility as affording a means of eliminating such difficulties as may attend the picking up of comparatively high-tension currents as is contemplated in the suggestion proposing the placing of step-down transformers and rotary converters on the locomotive. Opinions differ as to the electromotive force which can be reliably and safely taken to the locomotive through the media of traveling trollies. Some who are skilled in high tension applications place the limit at 2000 volts as a maximum with preference for a lower potential, while others of equal experience and judgment state that they would not hesitate to apply 5000 volts to the trolley in overhead polyphase traction work. Lieutenant Stuart Smith's suggestion however, obviates the difficulties which attend the use of these high pressures.

◆

The means by which the three-phase high-tension current may be taken to the locomotive is in no event the simple process that it may appear to be. Three-phase current will of course be used if for no other reason than that it requires a lesser number of traveling contacts than any other system. Naturally, the rail will form one side of the circuit, as is universally done in direct-current railway practice. The other two sides of the three-phase circuit must then be taken either from two overhead trolley wires or from a single trolley and a third rail as above suggested. In the first instance, the two trolley poles must be separate and entirely independent—which is easy—and the two trolley wires must be highly insulated from each other under all conditions of service and of weather—which is difficult. As to the third-rail system, its use can hardly be considered seriously in high-tension polyphase traction unless it be applied to elevated railway service.

◆

Another correspondent deals solely with methods of control for induction motors when used for railway work, and in his communication is discussed five systems through the use of either of which such motors may be made to fulfill the conditions imposed in various degrees of satisfaction. These five methods are:

First: By the use of motors having primary and secondary wound for the same voltage, alternations and number of poles. With this method, regulation for half-speed and below is effected by connecting the primary of the first motor to the line, the secondary of the first motor to the primary of the second motor, and short-circuiting the secondary of the second motor through suitable resistance. On the other hand, regulation from half-speed to full-speed is obtained by putting the primaries of both motors to line, and short-circuiting their secondaries through suitable resistance. The coupling of motors in this manner is sometimes termed placing them in concatention.

In this case the impressed voltage is kept constant, but the controller with the accompanying resistance is altogether quite complicated. Where the two motors are in series, and the primary of the first is connected to line, the exciting current of the first is double its normal exciting current and it has practically double the losses, which give rise to very undesirable conditions.

Second: The use of two motors wound as in the preceding case, but which are not operated in series. In this case, speed changes of all degrees up to full speed are accomplished by the introduction of resistance into the secondary windings of the motors.

Third: The use of motors containing primary windings of usual forms and squirrel-cage secondaries, the changes of speed therein being effected by means of variable impressed voltage.

Fourth: The use, preferably, of a single motor containing eight poles with leads brought out so as to connect the same windings for four poles, the secondary being of the squirrel-cage type. With this method the controller is complicated on account of the many connections necessary to change the number of poles from four to eight, and to the further fact that the eight-pole combination takes current at approximately one-half the voltage as does the four-pole combination.

Fifth: A motor or independent motors having primaries which are wound with two separate windings, one being for a complete four-pole winding and the other being for a complete and separate eight-pole winding, the secondaries being of the squirrel-cage type. Variations in speed, when this method is used, are obtained by changing from one winding to the other and also by varying the impressed voltage. The controller for this method is not very complicated.

Method No. 1 possesses the disadvantages that the first motor is apt to be much overloaded and the controller is complicated.

Methods 2 and 3 are much used for crane work, but both are inefficient at low speeds. Each have the advantage of simplicity, the latter being the more simple because of its squirrel-cage secondary. The relative advantages between the two depend upon whether the speed curve in No. 3 can be made practically a straight line without sacrificing the efficiency or power factor more than in case 2.

Methods 2 and 3 can be used successfully for heavy traction where long-sustained slow speed is not necessary.

Methods 4 and 5 depend upon the use of a different number of poles for giving two distinct synchronous speeds.

With No. 4, the complications are in the controller.

With No. 5, the complications are within the machines, but the controller becomes simple.

The hope for alternate-current electric traction lies between methods 4 and 5 until something better appears. Experience has shown that in street car work, two speeds are practically all that are required for continuous, long-sustained runs, and it is reasonable to believe that with the two speeds given under methods 4 and 5, the problem may be solved.

THE BLUE LAKES FIRE.

The details attending the destruction of the power house of the Blue Lakes Water Company, near Mokelumne Hill, early on the morning of November 1st, are given on another page of this issue and the interested public will be glad to know that the report of the fire as there given is authentic, as it emanates from the officials of the company upon which falls the burden of the loss. The plant was uninsured and its destruction was almost total, for practically the only salvage will rest in the generators and water wheels which can be put in service again at a comparatively slight cost. It is understood that the plant will not be rebuilt upon the old site but instead a new station will be erected some two miles further up the Mokelumne River where better reservoir sites and a higher head are available.

The catastrophe has excited much interest if not concern, principally because of the fact that it presents the first instance of the destruction of an electric transmission plant by fire, and, secondarily, because of the rapidity with which the structure was consumed. Of the first cause of interest, nothing need be said beyond extending the reminder—so prone to lay dormant and unheeded—that no building containing wooden floors, partitions and platforms, can or ever will be fire-proof. In the present case the framework of the building was of steel, the roof and sidings of corrugated iron, and the foundations and wheel and generator pit were of concrete. The electrical equipment throughout was of types which are accepted as fire-proof the world over, and so far, but no farther, could the plant be accepted as an A1 fire risk; for the presence of wooden floors, partitions and platforms more or less oil-soaked, and of great quantities of oil, all conspired to wreck the plant at the fatal moment when at last the unexpected occurred.

But it cannot be said that the occurrence of fire amid such surroundings should be altogether unexpected unless it be by the companies themselves, each of which that has undergone similar experiences has found too late that it has been under the hallucination that *its* plant could not burn. Insurance adjusters know this story too well, for it is told with variations at each settlement of a fire loss. Anything, everything, will burn, but the liability of fire will be reduced if not practically eliminated, by the rigid exclusion of every piece of timber and of every combustible from within the premises. This is not impossible in central station practice, if wire insulations alone be excepted, but to the contrary it expresses hard common sense, if self-preservation is a desideratum.

The lessons of the fire are few, but they are potent.

First, make power houses fire-proof and provide them with fire-fighting facilities according to the instructions of fire underwriters.

Second, do not concentrate all exciter, generator, transformer and station wiring, instruments and devices into a single switchboard—instead, separate them wherever possible, keep all interlinking wires, feeders and 'bus bars in roomy subways, and, in brief, segregate all station equipment so that each piece of apparatus shall be independent of all others as to methods of protection and control, to the greatest possible degree.

Third, the vitals of an electrical system are located in its power house, the destruction of which in an hour may occasion losses in business and prestige which might consume a decade in rehabilitating. Finally, of the many thousands of dollars, if not tens of thousands of dollars, that are being spent in the betterment and extensions of water supplies, pole lines and general plant, spare a few hundreds for the improvement of power houses and substations as fire-risks. If not, your plant may be the next to burn for thus far by no means all electric power houses are invulnerable to loss by fire.

Gas

INDUSTRIAL GAS.—VIII.

BY FRANK H. BATES.

VAPOR TENSION OF LIQUIDS. The pressure due to the tendency of volatile liquids to evaporate is termed vapor tension.

Vapor escapes from the surface of volatile liquids more or less readily at all temperatures, creating a pressure which varies with the temperature and is dependent upon the nature of the liquid. With the same liquid however, under like conditions of temperature, this pressure or vapor tension, as it is termed, remains constant.

With increase of temperature the vapor tension becomes greater, until it equals the external or atmospheric pressure, when what is termed boiling occurs—bubbles of vapor forming, and, in bursting, violently agitating the surface of the liquid.

Vapor tension varies with the nature of the liquid; it is consequent then, that the temperatures at which *different* liquids boil will vary under like conditions of pressure.

The boiling point is defined above as the temperature at which the vapor tension becomes equal to the external pressure; it follows then, that as the external or atmospheric pressure varies, the boiling point also changes. With a decrease of the external pressure acting upon a liquid, the temperature of boiling is reduced, since the vapor tension need not become as high to equal the external pressure, and similarly with increased external pressure the boiling point is raised.

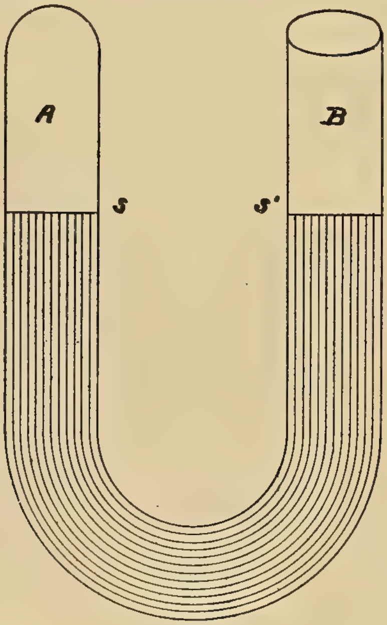


FIGURE 26.

At the temperature of boiling the vapor tension equals the external pressure; this fact affords a ready means of determining the tension of different liquids, since it is but necessary to note the external pressure (by means of a barometer if atmospheric), and the temperature at which the liquid boils.

Effect of Vapor Tension on Volume. When a gas is measured over a liquid such as water or mercury, part of the gas volume may be vapor, dependent upon the temperature at which the measurement is made. To assist in separating the true gas volume from the liquid vapor, Table II has been compiled, since by previously determining the vapor tensions of the liquids employed for different temperatures, we may easily make corrections for the measured volumes. The accompanying illustration will serve to make this clear. It is desired to measure the volume of a gas, over water, in the closed arm A of the U tube, Figure 26. The water over which the measurement is made is at the same level as S and S' in both arms of the tube, indicating an external pressure equal to that within the closed arm. The pressure in the latter is, however, made up of both that exerted by the gas volume and that of the vapor tension. If we let

P_a = the atmospheric pressure in millimeters of mercury = the barometer reading,

P_t = the tension of water vapor at the temperature at which the measurement was made (found in Table II of vapor tensions),

P = the net or true pressure exerted by the gas to be measured.

Then,

P (true pressure) = P_a (atmospheric pressure) — P_t (vapor tension).

Consequently, in taking account of the tension of vapor in the measurement of a gas volume, it is but necessary to find the true pressure (atmospheric less pressure due to vapor tension) for use in reducing to standard conditions.

The true or net pressure will, of course, always be less than atmospheric or that indicated by the barometer.

Let us consider the following example:

A volume of ethylene, C_2H_4, measured over water, under a pressure of 750 millimeters of mercury, and at a temperature of 21° C., gave a volume of 2 liters. What would its volume be under standard conditions of pressure and temperature, and when making correction for vapor tension?

We have:

Pressure measured under...	=	750 mm. of mercury,
Standard pressure..............	=	760 mm. of mercury,
From table, vapor tension of water at 21° C...............	=	18.495 mm. of mercury,
Pressure corrected for vapor tension = 750 — 18.495...	=	731.505 mm. of mercury,
Temp'ture measured under = 21° C., or 273 + 21...	=	294° C., absolute,
Standard temp'ature = 0° C.	=	273° C., absolute.

We have then:

$$2 \times \frac{750}{760} \times \frac{273}{294} = X, \text{ or } X = 1.83 \text{ liters}$$

as the volume when the pressure is uncorrected for vapor tension; and

$$2 \times \frac{731.505}{760} \times \frac{273}{294} = X, \text{ or } X = 1.78 \text{ liters}$$

as the volume when the pressure is corrected for vapor tension.

1.83 — 1.78 = 0.05 liters = the difference due to the presence of water vapor, which, had it not been taken into account, would have been considered as gas.

The foregoing tends to emphasize the necessity of making corrections for vapor tension where great accuracy is required in the measurement of gas volume.

When a gas is measured over a liquid not easily volatile at ordinary temperatures, such as mercury, it may be saturated, previous to measurement, with water vapor by simply introducing a drop or so of water.

When the measurement is made over water, the gas will always be saturated. This is a necessary condition in order that use may be made of the tables of vapor tension, the tensions being known only for saturated gases.

In measuring perfectly dry gases over mercury at ordinary temperatures, no correction for vapor tension need be made, since the tension of vapor of mercury is but slight, and furthermore, is offset by a like tension of the mercury of the barometer at atmospheric pressures. It is but necessary in this case then, to simply make certain that both the barometer and gas volume being measured, are subject to like temperature and pressure, when the mercury of the barometer will stand lower on the scale by just the amount of the tension of mercury, due to the temperature acting on it, giving a reading therefore, equal to the true pressure to which the gas volume is subject.

In event of gases being measured over mercury at temperatures higher than the barometer is subject to, then the difference of vapor tension at the two temperatures (that of the barometer and that of the gas volume) should be subtracted from the atmospheric pressure to determine the true pressure.

The expansion of mercury at high temperatures must also be taken into account. The preferable method is, therefore, to keep the temperatures of both the gas volume (to be measured over mercury) and of the barometer the same whenever possible, thus obviating all necessity for correction for the tension or expansion of the mercury.

Table III gives the tension of mercury vapor at various temperatures.

HEATING VALUE OR CALORIFIC POWER.

By *calorific power* is implied the quantity of heat which may be derived from the combustion of unit volumes or unit weights of a given fuel.

The term *combustion* may be defined as rapid chemical combination, and is generally considered as the combination of some element or elements—usually carbon or hydrogen or both—with oxygen, with a resulting evolution of heat and light.

To facilitate comparative measurements of the heat of combustion of various substances, a *quantitative unit of heat* has been adopted as standard. This, for the English-speaking countries, is the British thermal unit, and for the French-speaking countries, the calorie.

The *British thermal unit* may be defined as the quantity of heat which is required to raise the temperature of one pound of pure water one degree Fahrenheit, at or near 39.1° F.—the temperature of maximum density of water.

The *calorie* is the quantity of heat which is required to raise the temperature of one kilogramme of pure water one degree Centigrade, at or about 4° C., which is equivalent to 39.1° F.

Since both the French and English systems are used in the measurement of quantity in this country, a knowledge of how to convert a unit of one system to the other is often of assistance when tables are not accessible.

To change degrees Centigrade to Fahrenheit or Fahrenheit to Centigrade. In the Centigrade thermometer the freezing point of water is taken as 0°, and as 32° on the Fahrenheit. The boiling point of water is taken as 100° on the former and as 212° on the latter. This gives a range of 100 degrees between the freezing and boiling points of water on the Centigrade scale, and of 180 degrees on the Fahrenheit; consequently, designating degrees Centigrade and Fahrenheit by C. and F. respectively, we have:

$$\text{C.} : \text{F.} :: 100^\circ : 180^\circ;\ \text{or,}$$

$$\text{C.} = \frac{100}{180}\,\text{F.} = \tfrac{5}{9}\,\text{F.} = 0.556\ \text{F.},\ \text{and}$$

$$\text{F.} = \frac{180}{100}\,\text{C.} = \tfrac{9}{5}\,\text{C.} = 1.8\ \text{C.},$$

hence we have, calling t_c, temperature Centigrade, and t_f temperature Fahrenheit:

$$t_c = 0.556\,(t_f - 32^\circ) \text{ and } t_f = 1.8\,t_c + 32^\circ.$$

We have then the following rules:

To change degrees Centigrade to Fahrenheit, multiply the degrees Centigrade by 1.8 and add 32 to the product; and, *to change degrees Fahrenheit to Centigrade*, subtract 32 from the degrees Fahrenheit and multiply the remainder by 0.556.

To change British thermal units (B. T. U.) to calories (c.) or calories to British thermal units.

1° C. $= \frac{9}{5}^\circ$ or 1.8° F.;

1° F. $= \frac{5}{9}^\circ$ or 0.556° C.;

1 kilogramme = 2.2046 pounds;

1 pound = 0.4536 kilogrammes;

1 calorie = 1 kilogramme (2.2046 pounds) of water raised through 1° C. (1.8° F.), or

1 calorie = 2.2046 × 1.8 = 3.968 British thermal units, since

1 British thermal unit = 1 pound (0.4536 kilogrammes) of water raised through 1° F. (0.556° C.), and similarly

1 British thermal unit = 0.4536 × 0.556 = 0.252 calories; consequently

To convert calories into British thermal units, multiply by the constant 3.968, and

To convert British thermal units into calories, multiply by the constant 0.252.

British thermal units are generally given per cubic foot or per pound, and calories per cubic meter (or liter = .001 cubic meters) or per kilogramme.

1 cubic meter = 35.314 cubic feet;

1 cubic foot = 0.02832 cubic meters; consequently

To convert calories per cubic meter into British thermal units per cubic foot, multiply the calories by 3.968, giving

British thermal units per cubic meter, and divide the product by 35.314, when the quotient will be the number of British thermal units per cubic foot.

Since 3.968 ÷ 35.314 = 0.11236 the operation may be shortened by simply multiplying the calories per cubic meter by the constant 0.11236. Similarly,

To convert calories per kilogramme into British thermal units per pound, multiply the calories by 3.968, giving British thermal units per kilogramme, and divide the product by 2.2046, when the quotient will be the number of British thermal units per pound.

Since 3.968 ÷ 2.2046 = 1.8 (approximately), the calories per kilogramme may be multiplied by the constant 1.8, giving the number of British thermal units per pound directly as in the previous case.

To convert British thermal units per cubic foot into calories per cubic meter, multiply the British thermal units by 0.252, giving calories per cubic foot, and divide the product by 0.02832, when the quotient will be the number of calories per cubic meter.

Since 0.252 ÷ 0.02832 = 8.898 (approximately), the British thermal units per cubic foot may be multiplied by the constant 8.898, giving the number of calories per cubic meter directly. Similarly,

To convert British thermal units per pound into calories per kilogramme, multiply the British thermal units by 0.252, giving calories per pound, and divide the product by 0.4536, when the quotient will be the number of calories per kilogramme.

Since 0.252 ÷ 0.4536 = 0.556 (approximately), the British thermal units per pound may be multiplied by the constant 0.556, giving the equivalent number of calories directly.

Another unit often employed in connection with the quantitative measurement of heat by scientific writers is the *thermal unit*, which may be defined as the quantity of heat required to raise one pound of pure water one degree centigrade at or about 4° C.

To change British thermal units to thermal units, or thermal units to British thermal units.

Since 1° C. = $\frac{9}{5}^\circ$ F., or 1.8° F., and
1° F. = $\frac{5}{9}^\circ$ C., or $.556^\circ$ C.

To convert British thermal units into thermal units, multiply the British thermal units by the constant, 0.556.

To convert thermal units into British thermal units, multiply the thermal units by the constant, 1.8.

The term *temperature* should not be confused with quantity of heat, since it is used but to express the intensity of heat at any one time. A match in burning may develop considerable temperature as well as evolve a certain quantity of heat, whereas a quantity of iron combining with oxygen to form iron oxide or rust, will apparently fail to show any increase in temperature, yet before its combustion is complete the quantity of heat evolved may greatly exceed that resulting from the combustion of the match. Temperature is then but a factor in quantity of heat.

The definition of the unit of heat affords a clue to the

TABLE II.

Tension of water vapor in millimeters of mercury for different temperatures. Also the weight in grams of the vapor contained in a cubic meter of air when saturated.

Degrees Centigrade	Tension in Millimeters	Weight in Grams	Degrees Centigrade	Tension in Millimeters	Weight in Grams	Degrees Centigrade	Tension in Millimeters	Weight in Grams
—20.	0.927		12.	10.457	10.6	26.4	25.588	
—10.	2.093		12.2	10.596		26.6	25.891	
—2.	3.955		12.4	10.734		26.8	26.198	
—1.8	4.016		12.6	10.875		27.	26.505	25.6
—1.6	4.078		12.8	10.019		27.2	26.820	
—1.4	4.140		13.	11.162	11.3	27.4	27.136	
—1.2	4.203		13 2	11.309		27.6	27.455	
—1.	4.267		13.4	11.456		27.8	27.778	
—0.8	4.331		13.6	11.605		28.	28.101	27.
—0.6	4.397		13.8	11.757		28.2	28.433	
—0.4	4.463		14.	11.908	12.	28.4	28.765	
—0.2	4.531		14.2	12.064		28.6	29.101	
0.	4.600		14.4	12.220		28.8	29.441	
+0.2	4.667		14.6	12.378		29.	29.782	28.6
+0.4	4.733		14.8	12.538		29.2	30.131	
+0.6	4.801		15.	12.699	12.8	29.4	30.479	
+0.8	4.871		15.2	12.864		29.6	30.833	
+1.	4.940		15.4	13.029		29.8	31.190	
+1.2	5.011		15.6	13.197		30.	31.548	29.2
+1.4	5.082		15.8	13.366		31.	33.405	
+1.6	5.155		16.	13.536	13.6	32.	35.359	
+1.8	5.228		16.2	13.710		33.	37.410	
+2.	5.302		16.4	13.885		34.	39.565	
+2.2	5.378		16.6	14.062		35.	41.827	
+2.4	5.454		16.8	14.241		40.	54.906	
+2.6	5.530		17.	14.421	14.5	45.	71.391	
+2.8	5.608		17.2	14.605		50.	91.982	
+3.	5.687		17.4	14.790		55.	117.478	
+3.2	5.767		17.6	14.977		60.	148.791	
+3.4	5.848		17.8	15.167		65.	186.945	
+3.6	5.930		18.	15.357	15.1	70.	233.093	
3.8	6.014		18.2	15.552		75.	288.517	
4.	6.097		18.4	15.747		80.	354.643	
4.2	6.183		18.6	15.945		85.	433.041	
4.4	6.270		18.8	16.145		90.	525.450	
4.6	6.350		19.	16.346	16.2	95.	633.778	
4.8	6.445		19.2	16.552		99.	733.21	
5.	6.534	6.8	19.4	16.758		99.1	735.85	
5.2	6.625		19.6	16.967		99.2	738.5	
5.4	6.717		19.8	17.179		99.3	741.16	
5.6	6.810		20.	17.391	17.2	99.4	743.83	
5.8	6.904		20.2	17.608		99.5	746.5	
6.	6.998	7.3	20.4	17.826		99.6	749.18	
6.2	7.095		20.6	18.047		99.7	751.87	
6.4	7.193		20.8	18.271		99.8	754.57	
6.6	7.292		21.	18.495	18.2	99.9	757.28	
6.8	7.392		21.2	18.724		100.	760.	
7.	7.492	7.7	21.4	18.954		100.1	762.73	
7.2	7.595		21.6	19.187		100.2	765.46	
7.4	7.699		21.8	19.423		100.3	768.20	
7.6	7.840		22.	19.659	19.3	100.4	771.95	
7.8	7.910		22.2	19.901		100.5	773.71	
8.	8.017	8.1	22.4	20.143		100.6	776.48	
8.2	8.126		22.6	20.389		100.7	779.26	
8.4	8.236		22.8	20.639		100.8	782.04	
8.6	8.347		23.	20.888	20.4	100.9	784.83	
8.8	8.461		23.2	21.144		101.	787.63	
9.	8.574	8.8	23.4	21.400		105.	960.41	
9.2	8.690		23.6	21.659		110.	1075.37	
9.4	8.807		23.8	21.921		120.	1491.28	
9.6	8.925		24.	22.184	21.5	130.	2030.28	
9.8	9.045		24.2	22.453		140.	2717.63	
10.	9.165	9.4	24.4	22.723		150.	3581.23	
10.2	9.288		24.6	22.996		160.	4651.62	
10.4	9.412		24.8	23.273		170.	5961.66	
10.6	9.537		25.	23.550	22.9	180.	7546.39	
10.8	9.665		25.2	23.834		190.	9442.70	
11.	9.792	10.	25.4	24.119		200.	11688.96	
11.2	9.923		25.6	24.406		220.	17390.	
11.4	10.054		25.8	24.697		224.7	25 atmospheres	
11.6	10.187		26.	24.988	24.2			
11.8	10.322		26.2	25.288				

TABLE III.

TENSION OF MERCURY VAPOR.

Degrees Centigrade	Tension in Millimeters	Degrees Centigrade	Tension in Millimeters	Degrees Centigrade	Tension in Millimeters
100	0.75	180	11.00	260	96.73
110	1.07	190	14.84	270	123.01
120	1.53	200	19.90	280	155.17
130	2.18	210	26.35	290	194.46
140	3.06	220	34.70	300	242.15
150	4.27	230	45.35	310	299 69
160	5.90	240	58.82	320	368 73
170	8.09	250	75.75	330	450.91

TABLE VI.

Owing to the necessity for frequent reference to both the French and English unit of measurement the insertion of conversion tables, etc., has been deemed advisable.

FRENCH MEASURE.

One Millimetre ($\frac{1}{1000}$ of a metre)	0.039370 inches
One Centimetre ($\frac{1}{100}$ of a metre)	0.393704 inches
One Decimetre ($\frac{1}{10}$ of a metre)	3.937043 inches
One Metre (unit of length)	39.370432 inches
One Decametre (10 metres)	393.704320 inches
One Hectometre (100 metres)	3937 043196 inches
One Kilometre (1000 metres)	39370.431960 inches
One Myriametre (10,000 metres)	393704.319600 inches or, 6 miles, 376 yards, 0 feet and $8\frac{5}{16}$ inches

TABLE VII.

FRENCH WEIGHTS.

One Milligramme ($\frac{1}{1000}$ of a gramme)	0.0154 grains =	0.0000022 avoirdupois lbs.
One Centigramme ($\frac{1}{100}$ of a gramme)	0.1543 grains =	0.0000220 avoirdupois lbs.
One Decigramme ($\frac{1}{10}$ of a gramme	1.5432 grains =	0.0002204 avoirdupois lbs.
One Gramme (unit of weight)	15.4323 grains =	0.0022046 avoirdupois lbs.
One Decagramme (10 grammes)	154.3234 grains =	0.0220462 avoirdupois lbs.
One Hectogramme (100 grammes)	1543.2348 grains =	0.2204621 avoirdupois lbs.
One Kilogramme (1000 grammes)	15432.3487 grains =	2.2046212 avoirdupois lbs.
One Myriagramme (10,000 grammes)	154323.487 grains =	22.0462124 avoirdupois lbs.
One Quintal (100,000 grammes)	1543234.87 grains =	220.462124 avoirdupois lbs.
One Millier (1,000,000 grammes)	15432348.7 grains =	2204.62124 avoirdupois lbs.
1016.0475443 Kilogrammes	15680000.0 grains =	2240. avoirdupois lbs. = one long ton
0.45359265 Kilogrammes	7000.0 grains =	1. avoirdupois lb.
0.37324 Kilogrammes	5760.0 grains =	1. troy pound

TABLE VIII.

VOLUME—CAPACITY.

One Cubic Metre	35.314 cubic feet 1.308 cubic yards
One Cubic Yard	0.7645 cubic metres
One Cubic Foot	0.02832 cubic metres
One Cubic Decimetre	61.023 cubic inches 0.0353 cubic feet
One Cubic Foot	28.32 cubic decimetres
One Cubic Centimetre	0.061 cubic inches
One Cubic Inch	16.387 cubic centimetres
One Cubic Foot	28.317 litres

One Liter ($\frac{1}{1000}$ cubic metre or one cubic decimeter)	61.023 cubic inches 0.03531 cubic foot 2.1135 pints 1.0567 quarts (American) 0.2642 gallons (American) 2.202 pounds of water at 62° F.
One Gallon (American—231 cubic inches)	3.785 litres
One Gallon (British—277.274 cubic inches)	4 543 litres
One Quart (57.75 cubic inches)	946.30 cubic centimetres
One Pint (28.875 cubic inches)	473.15 cubic centimetres

TABLE IX.

WEIGHT—MASS.

One Milligramme	0.015432 grains
One Grain	64.799 milligrammes
One Gramme	15.43235 grains
One Grain	0.064799 grammes
One Gramme	0.03215 ounces (troy)
One Ounce (troy—480 grains)	31.10348 grammes
One Gramme	035274 ounces (avoirdupois)
One Ounce (avoirdupois—437.50 grains)	28.35 gram's
One Kilogramme	2.2046 pounds (avoirdupois)
One Pound (avoirdupois—7000 grains)	0.45359 kilogrammes
One Pound (troy—5760 grains)	0.37324 kilogrammes

	Milligrammes to Grains	Grains to Milligrammes	Grammes to Grains	Grains to Grammes	Grammes to Ounces (avoirdupois)	Ounces (avoirdupois) to Grammes	Grammes to Ounces (troy)	Ounces (troy) to Grammes	Kilogrammes to Pounds (avoirdupois)	Pounds (avoirdupois) to Kilogram's
1=	0.01543	64.7989	15.43235	0.064799	0.035274	28.3495	0.03215	31.10348	2.20462	0.45359
2=	0.03086	129.5978	30.86470	0.129598	0.070548	56.6991	0.06430	62.20696	4.40924	0.90719
3=	0.04630	194.3968	46.29705	0.194397	0.105822	85.0486	0.09645	93.31044	6.61386	1.36078
4=	0.06173	259 1957	61.72940	0.259196	0.141096	113.3981	0.12860	124.41392	8.81849	1.81437
5=	0.07716	323.9946	77.16175	0.323995	0.176370	141.7476	0.16075	155.51740	11.02311	2.26796
6=	0.09259	388 7935	92.59100	0.388794	0 211644	170.0972	0.19290	186.62089	13.22773	2.72156
7=	0.10803	453.5924	108.02645	0.453593	0.246918	198.4467	0.22505	217.72437	15.43235	3.17515
8=	0.12346	518.3914	123.45880	0.518392	0.282192	226.7962	0.25721	248.82785	17.63697	3.62874
9=	0.13889	583.1903	138.89115	0.583191	0.317466	255.1457	0.28936	279.93133	19.84159	4.08233
10=	0 15430	647.9890	154.32350	0.647990	0.352740	283.4950	0.32150	311.03480	22.04620	4.53590

principles upon which the construction of instruments for quantitative heat measurement are based. They are generally designed so as to allow of the absorption of the total heat of combustion of the substance being tested by a body of water, indicating the quantity of heat either by measurement of the volume and the rise in temperature of the water, or by measurement of the expansion of the water.

(To be continued.)

Generation

REGULATING SECONDARY VOLTAGES.

IN the operation of rotary converters, in feeding both moderately high and low tension alternate current distributions, in controlling series a. c. street-lighting circuits; in adjusting potentials in different branches of unbalanced polyphase or three-wire circuits; in special work such as the manufacture of carborundum,* and, in fact, wherever it is desired to obtain alternating currents of variable pressure, the induction regulator in one or another of its several forms will be found to fully satisfy whatever exigency may be imposed. It raises or lowers the voltage of a circuit, or, in polyphase work, of any leg of a circuit, without change of connection; it varies the voltage continuously without abrupt stops or breaks; it has no moving contacts; its adjustments of pressure are independent of the current in the circuit; it may be controlled by either manual or automatic means; and, in its best forms, its power factor is high.

The earliest type of potential regulator, and which as well constituted the type first installed by the carborundum company, is illustrated diagramatically in Diagram I. Its primary was wound to suit the voltage of the circuit; its secondary was of sufficient capacity to carry the maximum current of the circuit, and its rated output was found in the product of the secondary ampereage into the maximum required rise or drop in volts. In the diagram is given the potentials as used in this type of regulator by the carborundum company. The primary of the reducing transformer is connected directly across the 2,200-volt circuit. The secondary is connected in series with the secondary of the regulator, the primary of which is connected to the secondary terminals of the transformer. The regulator is simply a transformer in which the relative positions of primary and secondary windings may be so changed that from a position where the whole flux generated by the primary cuts the secondary effectively and consequently where the secondary voltage is a maximum, the positions may be gradually changed to a point where the primary flux has no effect upon the secondary, and therefore when the secondary voltage is zero. If the movement is continued past the zero point the secondary voltage will begin to increase, but in a reverse direction, until it again reaches a maximum. Since the secondary of the regulator is in series with the secondary of the transformer, its voltage will be added to or substracted from that of the transformer, as the case may be, so that the voltage on the furnace may be varied from the sum of transformer and regulator voltage to the difference between the two. The variation is gradual, and no sudden fluctuations are possible. In the carborundum works the ratio of the transformer is 2,200 to 185, and that of the regulator 185 to 75; there may thus be delivered to the furnace an electromotive force varying from 110 to 260 volts. The output of the transformer is 830 kilowatts. The current will therefore vary from 7,545 amperes at 110 volts to 3,102 amperes at 260 volts. At the lowest voltage the regulator must therefore be able to deliver 7,545 amperes at 75 volts or 565 kilowatts.

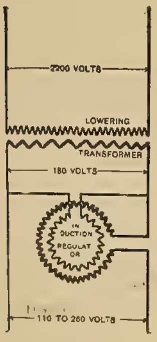


DIAGRAM I.
MR REGULATOR.

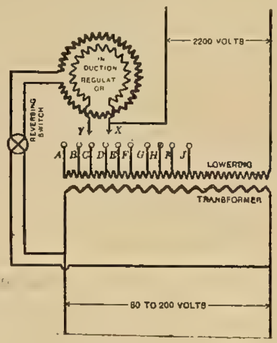


DIAGRAM II.
ROWE REGULATOR.

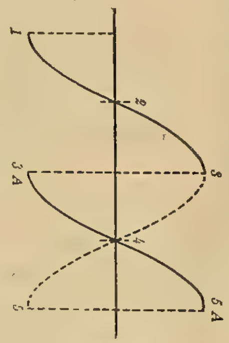


DIAGRAM III.
VOLTAGE LOOPS.

An induction regulator of this size is an expensive piece of apparatus to build, for it is difficult to keep cool, and it must be of sufficient capacity to take the entire ampereage of the load. Moreover, its power factor is apt to be low in such enormous units. To obviate this, Norman Rowe, now engineer for the San Francisco office of the Westinghouse Electric and Manufacturing Company, suggested that a combination of the "loop" and "induction" methods of regulation might be effected with very considerable advantage. This method of regulation consists in bringing out loops from the primary of the transformer and of using an induction regulator for stepping from loop to loop on the winding. When it is desired to obtain a variable secondary voltage from a transformer whose primary is supplied with a constant voltage, the simplest method is to bring out loops from the primary or secondary windings, and by means of these loops change the ratio of primary to secondary turns, but this method of regulation is only permissible when small jumps in voltage are not objectionable, and therefore could not be used in this particular plant.

In Diagram II are shown the connections of transformers and regulator where the Rowe method is employed. *A*, *B*, *C*, *D*, *E*, etc., are loops brought out at equal intervals from the primary of the transformer. The primary of the regulator is connected across the secondary terminals of the transformer, while the secondary is in series with the primary of the transformer, as indicated in diagram. Diagram III shows the change in the secondary voltage of the regulator as it is rotated. Suppose the regulator to be in position 1, so that it is generating its maximum electromotive force, and in a direction opposing that of the primary circuit; then the terminal *Y*, being connected to the loop *A*, it is evident that the secondary voltage of the transformer will have its minimum value, for all primary turns are in circuit, and the regulator voltage opposes that of the line. If the regulator be now rotated its secondary voltage will begin to decrease and the secondary voltage of the transformer to increase, until position 2 has been reached, where the regulator voltage, being zero, has no effect on the voltage of the circuit. As the rotation of the regulator is continued its voltage will begin to increase, adding itself to that of the line and increasing the voltage of the transformer. When position 3 has been reached the voltage from *X* to *Y* is exactly equal to the voltage from *A* to *B* (this being the ratio for which the regulator is wound), and *X* and *B* may be connected with no change in voltage on the transformer. In this position the line terminal *X* is connected directly to the terminal *B*, so that *Y* and *A* may be disconnected without spark and without change in voltage. If now the primary of the regulator be reversed, the secondary voltage will be that shown in position 3 *A*, and will be equal to that from *B* to *C*, so that *Y* may be connected to *C*, and then *X* disconnected from *B* without changing the voltages of the system. The regulator now bears the same relation to the point *C* that, at the start, it did to the

---

*See *The Electrical World*, Vol. XXXIII, page 16, January 7, 1899.

point *A*, so that if the rotation be continued the secondary electromotive force will be gradually increased as before, and at the proper point *X* may be connected to *D*, *Y* disconnected from *C*, the primary of the regulator reversed, *Y* connected to *E*, *X* disconnected from *D*, etc. It will be noted that although in passing from *A* toward *E* the voltage between loops is increasing, the primary voltage of the regulator is also increasing, so that the maximum secondary voltage of the regulator is always just equal to that between adjacent loops. The maximum voltage on secondary of transformer will be obtained when *Y* is connected to *J*, and the maximum voltage of the regulator is added to that of the line. It is evident that to reduce the secondary voltage of the transformer it is only necessary to reverse the direction of rotation of the regulator, so that it moves along the loops from right to left, the minimum voltage being obtained when *Y* is connected to *A*, and the maximum voltage of the regulator opposes that of the line.

The numerous loops from the primary of the transformer and the primary and secondary terminals of the induction regulator are carried to a dial, on which are made the proper changes in connections from point to point. This dial is rigidly fastened to the top of the regulator, a hand-wheel at the side of which is connected through a worm gear to the secondary of the induction regulator, and through bevel gears to the contact fingers on the dial. When the hand-wheel is turned, the secondary of the regulator is rotated until a maximum secondary voltage is obtained; at this point a spring inside the dial, which has been put in tension by the rotation of the secondary, is released and carries through the series of changes necessary in stepping from one contact to the other; *i. e.*, *X* is connected, *Y* is disconnected, the primary is reversed, *Y* is advanced to the proper contact, and *X* is disconnected.

When the transformer at the carborundum works delivers its full load of 750 kilowatts, the current in the secondary of the regulator is approximately 340 amperes, and as the maximum secondary voltage is 100, the maximum capacity of the regulator is only 34 kilowatts. The energy loss in a regulator of this type is much less than that of the earlier forms of potential regulators, and, moreover, as its magnetizing current is very much lower, its power factor is considerably higher.

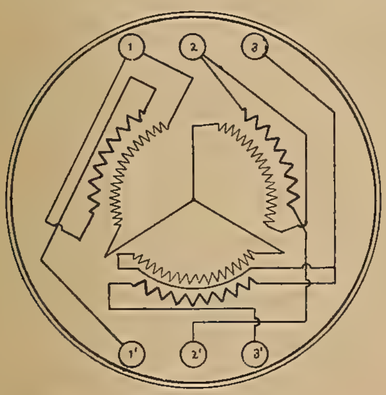


DIAGRAM IV.
THE IRT REGULATOR.

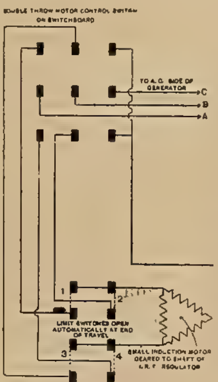

DOUBLE THROW MOTOR CONTROL SWITCH ON SWITCHBOARD
TO A.C. SIDE OF GENERATOR
C
B
A
1
2
3
4
LIMIT SWITCHES OPEN AUTOMATICALLY AT END OF TRAVEL
SMALL INDUCTION MOTOR GEARED TO SHAFT OF I.R.T. REGULATOR

DIAGRAM V.
THE IRT CONTROLLER.

The General Electric Company has brought out a new form of induction regulator known as the IRT type, which is illustrated diagramatically in Diagram IV. This is the regulator used in the sub-station of the Folsom-Sacramento transmission, at Rossland, B. C., and elsewhere. As in the previous General Electric regulator, it has no moving contacts, but is adjusted by moving an iron core in either direction through an arc of 50 degrees or thereabouts, which varies the inductive effect of a shunt winding on a series coil. How this is done appears in Diagram IV. The IRT regulator resembles an induction motor in form inasmuch as it possesses the usually well defined field or stator, and the rotor as well, the difference between it and the induction motor being that in the regulator the stationary or field windings are in three sections respectively, forming the leg of the main three-phase circuit, or in other words, the stator circuits are in series with the main circuit. The movable, or rotor windings are similarly cut into three sections, which are placed in shunt with the main circuit on the star connection. This movable part containing the so-called rotor windings is mounted on bearings as in an induction motor, and may be moved by hand, although for convenience in operating from a distance there is generally installed a small three-phase motor to drive the core in either direction by a worm gear, the motor being controlled from the switch board in the manner described in Diagram V. The control switch for this function is a triple-pole, double-throw switch by means of which the connections of one of the leads on the small motor is reversed. Electrically interposed between this control switch and the motor, however, are the limiting switches which open the small motor circuit automatically at the ends of travel. The manner in which this motor with its gearing and the limiting switches are mounted on the regulator is shown on page 88 of the JOURNAL for June last. These regulators may, of course, be made for any desired range of voltage.

A 25,000-VOLT DIRECT-CURRENT TRANSMISSION.

DIRECT current generators for the proposed 42-mile 10,000 horse-power St. Maurice-Lausanne transmission in Switzerland, are being built by the Compagnie de l'Industrie Electrique. It is proposed to use direct current at a maximum potential of 25,000 volts, and the generators, which are practically large arc machines, are to deliver constant current at variable voltage.

While no information concerning the details of this proposed transmission is at hand, it probably contemplates the use of the Thury system of power transmission by means of continuous currents, which is in use at the Val de Travers (1,000 horse-power, 10,400 volts, 21 miles), Chaux da Fond and Lock (3,200 horse-power, 14,400 volts, 25 miles), Brescia (500 horse-power, 7,000 volts, 25 miles), and elsewhere. In the Thury system,* the high electromotive force is obtained by coupling a number of series-wound generators in series, the drum winding being used up to 2,400 volts, and above that the gramme. Each generator is carefully insulated, the bed-plate resting on porcelain insulators imbedded in the foundation by means of a cement of sulphur and powdered glass. The coupling between generator and prime-mover consists of a pair of thick rubber discs connected by bolts. Two short-circuiting switches are provided for each generator, one being a hand switch, and the other an automatic switch controlled by a cam on the dynamo shaft so shaped that when the direction of rotation is reversed the switch immediately short-circuits the machine. The power is received at the distant station by means of similar series-wound motors connected in series, and used either directly as such or coupled to constant potential dynamos. Each motor is provided with a special regulator, which maintains the speed constant within 2 per cent. by acting on a shunt of variable resistance connected across the field.

MEASUREMENT OF LIGHT.

According to Abney, the photometric value of the illumination produced by the full moon is 0.012 candle feet, while the actual chemical value of it as shown by the effect on a sensitive photographic plate, is 0.266 candle feet. Very nearly the same ratio holds in reference to sunlight, which is chemically twenty-six times as active as an equal amount of candle light photometrically measured.

---

*See *Science Abstracts*, 1898, No. 874.

Industrial

In responding to advertisements in this publication kindly mention "The Journal of Electricity, Power and Gas."

INSULATING AND BAKING METHODS.

SOME information of value concerning standard methods of applying insulating varnish in electrical work, together with data for the building of baking ovens and directions for the use of the same, is contained in a circular recently issued by the Stilling Varnish Company. From this circular the following is quoted:

In insulating form-wound armature and field coils, the varnish is kept in a vat into which the coils are dipped without previous baking. The coils are kept in this vat until bubbles cease forming, when they are taken out and suspended directly over the vat, so that the excess of varnish may drip off. They are then carried to the baking room and baked at a temperature of about 85 degrees Centigrade for 12 to 24 hours, according to the size of the coils. By this method the vapor from the moisture contained in the cotton covering of the wire is driven through the coat of varnish during the process of drying.

With large armatures, and in cases where the wire is wound on the core, it is advised that the wire be wound dry, and that dry tape and canvas or linen be used in the ordinary way. The armature should then be placed in the baking room for 10 to 20 hours at from 85 degrees to 93 degrees Centrigrade, and then while still hot painted freely with the Sterling Extra Insulating Varnish and again baked for from 12 to 24 hours. For high resistance work a second coat should be applied in the same way. The fields are treated in a similar manner to the armature, except where inside insulation is desired, in which event they are painted with the varnish as they are being wound and then taped with dry tape, dipped or painted with the varnish and baked, one baking of 20 to 24 hours being sufficient.

Small armatures when wound dry should be given a preliminary baking in order to drive out moisture which is absorbed in the cotton covering of the wire during the process of winding. The armature should then be taken from the baking oven and immediately submerged in the dipping tank up to the level of the commutator, where the armature should remain until the varnsh has had sufficient time to penetrate to the bottom layers of the coils. An indication of this condition is apparent when the bubbles cease to rise to the surface. The armature is then lifted up over the vat, allowed to drip and placed in a baking oven, where it should be baked from 12 to 24 hours.

The baking temperature should not be higher than 93 degrees Centigrade for cotton covered wire, as cotton and paper fibre are destroyed by a higher temperature. The varnish will stand a higher temperature, and for use on metal such as armature core plates, baking at 120 degrees Centigrade is advised.

Further information, prices, etc., may be obtained from the Brooks-Follis Electric Corporation, Pacific Coast Agents, 523-525 Mission street, San Francisco.

TRADE LITERATURE.*

"Lundell Fan Motors, Catalogue 66." An artistic description, with all technical details, of the method of manufacture and features of advantage of Lundell direct and alternating current fans. 40 pages, 7x9 inches. Sprague Electric Company, New York; *Brooks-Follis Electric Corporation*, agents, San Francisco.

"Engine Type Generators." Bulletin No. 4434, illustrating and describing the leading distinctive features of the Bullock direct-current generators, with dimensional data in sizes from 15 kilowatts to 800 kilowatts. Ten pages. Bullock Electric Manufacturing Co., Cincinnati; *Wybro-Hendy Co.*, agents, San Francisco.

"Twenty-two Years' Use of Electrical Apparatus." A brochure illustrating and briefly descriptive of the 1877 and 1899 arc generators of the Brush type. The '99 type of machine itself, together with a number of representative installations of it in the largest sizes, together with station arc switchboards, are tastefully presented. Size, 5x7 inches; No. 1021, 30 pages. *General Electric Company.*

"Bullock Electric Power System for Operating Newspaper Presses." Bulletin No. 4428, illustrating and describing the "teaser" method of motor control for duty imposing variable speeds, as in newspaper presswork. By means of this method of control, economies are introduced which are impossible by other methods. Bullock Electric Manufacturing Company, Cincinnati; *Wybro-Hendy Company*, agents, San Francisco.

"The Victor Telephone Journal." A 24-page periodical of the size of the JOURNAL, devoted to the furtherance of the interests of the Victor Telephone Manufucturing Company and of the independent telephone industry. Although avowedly an advertising medium for Victor telephones, its first issue gives indication that it will contain much information of value to telephonists. Circulation gratuitous. Published at 205-7 South Canal street, Chicago.

"Electro-pneumatic Control for Railway and Other Motors." A 38-page catalogue devoted to a new system of control for electric motors on elevated or other railway service, the system involving the use of compressed air for moving the controlling apparatus, the admission of air into the several parts being effected electrically by means of magnets attached to the air valves. The system is used on an experimental train between East Pittsburg and Wilmerding, the details of which are clearly described. *The Westinghouse Air Brake Company*, Pittsburg, Pa.

"Westinghouse Gas Engines." This is the catalogue for which the mechanical world has been waiting so long. It gives the principles of construction and operation of the Westinghouse gas engine in a way which, in conjunction with graphic illustrations of its working parts, is both simple and convincing, so that, in truth, it really forms a lecture on the working principles of the best type of gas engine thus far produced. The catalogue is gotten out in the usual superb style which characterizes Westinghouse publications. Size 9x7 inches, 67 pages. *Westinghouse Machine Co.*

Westinghouse Bulletins. Standard bulletins, descriptive of Westinghouse apparatus, were publiihed during June, July and August as follows: No. 147-D, "Multipolar D-C. Generators and Motors;" No. 189-B, "Plunger Type Switches for 1100 and 2200 volt A-C. Circuits;" No. 231, "Adjustable Jaw Switches for 600 volts or less;" No. 232, "A-C. Switchboards for Polyphase Circuits of 1100 or 2200 volts;" No. 233, "A-C. Switchboards, Type 8;" No. 234, "Standard Railway Switchboards;" No. 235, "A-C. Switchboards for Polyphase Circuits of 100 or 600 volts;" No. 236, "Single-Phase Alternators, 16,000 r. p. m., 1100 and 2200 volts;" No. 237, "D-C. Lighting and Power Switchboards, Type 5, 750 volts or less." *Westinghouse Electric and Manufacturing Co.*

Wagner Bulletins. These are the standard bulletins issued during October, 1899. No. 27, on "Automobile Charging Outfits" pertains to a self-contained, direct-coupled combination consisting of a Wagner alternating-current induction motor driving a Wagner direct-current generator for charging storage batteries from alternating-current circuits. Efficiency curves and dimensional data are given. Bulletin No. 28, on "Wrought Copper Terminals" is descriptive of a line of new lead and switch terminals which the Wagner company has just brought out. These are of wrought copper instead of the cast alloy heretofore used, and which alloy has a current-carrying capacity of from 30 to 50 per cent. of that of wrought copper. Bulletin No. 29, on "Type C Switches," illustrates a new form of cheap yet reliable and durable knife switch for 50 amperes and potentials not exceeding 250 and 600 volts respectively. *Wagner Electric Manufacturing Company.*

---

*Catalogues mentioned in this department will be mailed gratuitously on application to the concerns publishing them. When writing, mention THE JOURNAL OF ELECTRICITY, POWER AND GAS. Where addresses are not given, they may be found through reference to the Advertisers' Index on page iii.

THE JOURNAL OF ELECTRICITY, POWER AND GAS.

VOLUME VIII. SAN FRANCISCO, DECEMBER, 1899. NUMBER 6.

*Polyphase Transmission.**

BY CHAS. F. SCOTT.

THE alternating current when first introduced for lighting presented many new problems to the electrical engineer. Numerous difficulties and dangers were predicted by the theorist, but in ordinary service most of these have fortunately lain dormant. These difficulties are apt to appear, however, when alternating current work is attempted on a large scale. The introduction of large units, heavier currents, higher potentials or power service is apt to increase the effects of self-induction and capacity, so that they now demand careful consideration. The impetus that electrical engineering is receiving from the introduction of the polyphase system, which brings with it large units and long distances, naturally directs attention to the general problem of alternating current transmission and distribution.

ALTERNATING-CURRENT PROBLEMS.

A complete and exhaustive solution of this problem is by no means a simple one, and the attempted solutions generally lead to formulae and diagrams which are possibly even more perplexing than the phenomena. If even the electrician who devotes all his energy to new problems can scarcely keep abreast of the times, it is not surprising that the practical engineer and station manager become perplexed and confounded at the apparently erratic phenomena observed in practice or described in print. Theoretical articles appear on variation in wave form, harmonics, so-called Ferranti effects, increased resistance in conductors with alternating currents, hysteresis, peculiar magnetic circuits, resonance, oscillations, lag, capacity, self-induction. Many of these articles, although evidently intended to be of service in engineering, show apparently no adequate appreciation of the practical bearing and relation of the subjects treated. Consequently, the average engineer becomes bewildered and perplexed, and concludes that theoretical explanations are of little value to the practical man. There are, however, many problems of great practical importance which admit of fairly simple statement and explanation. The particular element to be considered in the present paper is the transmission circuit.

EXPERIMENTS ILLUSTRATING SELF-INDUCTION.

One of the fundamental characteristics of alternating current work is self-induction. The effect of self-induction is most readily shown by a simple experiment. A wire having a resistance of 10 ohms may be wound in a coil. Ten volts will send a continuous current of 1 ampere through this coil. An alternating current of a certain frequency will require 50 volts for forcing 1 ampere through the same wire (Fig. 1A). (In the diagrams the numbers above the circuit are for continuous current and those below are for alternating current.) If a 1-ampere 50-volt lamp be placed in series with the coil and a current of 1 ampere be passed through the two in series, the E. M. F. required for continuous current is 10 volts on the coil and 50 volts on the lamp, or 60 volts across the circuit, and the E. M. F. required for alternating current is 50 volts across the coil and 50 volts across the lamp, which gives, not 100 volts, but 78 volts measured across the two in series (Fig. 2). If two lamps be placed in multiple and connected in series with the coil, 2 amperes will require for continuous current 20 volts on the coil and 50 volts on the lamps, or 70 volts across the circuit. For alternating current the E. M. F. on the coil is 100 volts and on the lamps 50 volts, and on the circuit across the two in series the E. M. F. is 120 volts (Fig. 3).

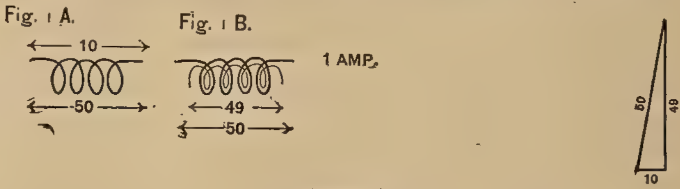


FIGURE 1.

The two lamps which are in multiple may be placed in series with a small coil. This small coil may be so proportioned in its number of turns and resistance that an E. M. F. of 50 volts will send 1 ampere alternating current through the combination (i. e., the small coil and the lamps), and a continuous current of 1 ampere would be caused by 35 volts. This combination may be treated as a unit and may be used to replace the single lamp in the above test (Fig. 2). If this combination be placed in series with the first coil (the one used in the first experiment) the E. M. F. required for sending the continuous current through the circuit will be 10 volts on the coil and 45 volts on the circuit. If the alternating current of 1 ampere be sent through the circuit, 50 volts will be required across the combination, and 50 volts across the coil, the same as with the single lamp, but the E. M. F. across the circuit is no longer 78 volts, but has increased to 95 volts (Fig. 4).

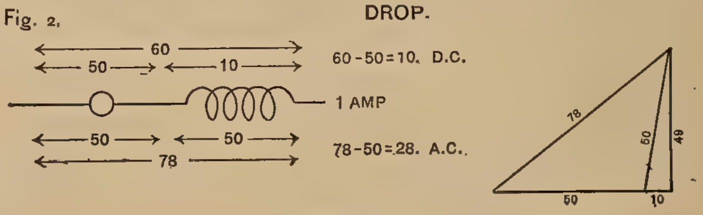


FIGURE 2.

The important facts to be noted in these experiments are: (1) That the sum of the alternating E. M. Fs. on the elements connected in series is greater than the E. M. F. required upon the terminals of the circuit; (2) that the alternating E. M. F. for supplying the lamps in series with a coil is greater than the continuous E. M. F., and (3) that the difference between the two becomes greater as the number of lamps is increased (Figs. 2 and 3). It is also to be noted (4) that if the same alternating current be supplied through a coil, first to a lamp alone and then to a combination including lamps and a coil, a higher E. M. F. is required when the combination is used (Figs. 2 and 4).

---

*A paper read before the National Electric Light Association, March 1, 1894, and revised by the author, 1899. Published through the courtesy of the Westinghouse Electric and Manufacturing Company.

Fig. 3.

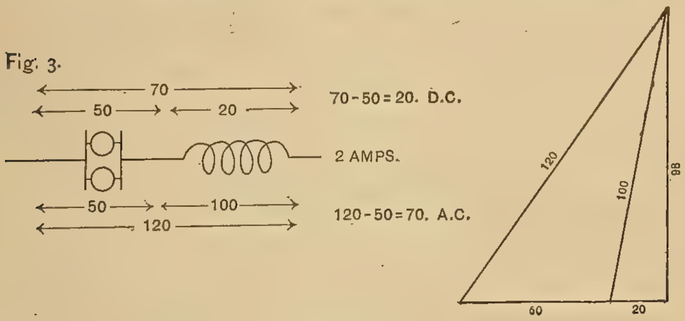


FIGURE 3.

These relations, which seem rather perplexing, may be illustrated in a very simple way by diagrams. In the case of the coil alone, in which 50 volts are required for producing 1 ampere alternating current and 10 volts for 1 ampere continuous current, these two E. M. Fs. may be represented by the hypotenuse and one side of the familiar right angle triangle. The remaining side represents the counter E. M. F. in the coil. If a second wire had been found in this coil in parallel with the first it would be found that when 1 ampere is passing there is an E. M. F. on the terminals of the second, or idle wire, of 49 volts (Fig. 1B). This E. M. F. is caused by the field produced by the alternating current. An equal E. M. F. is, of course, induced in the wire carrying the current, as the two wires occupy virtually the same position. This counter E. M. F. is seen to correspond with the third side of the triangle. Suitable measurements would show that this counter E. M. F. is not coincident with the current through the coil, but that its maximum value occurs when the current is passing through its zero. This relation is shown in the diagram by the 90-degree relation of the lines representing counter E. M. F. and the volts required for sending continuous current through the line. Triangular diagrams are also given in connection with a number of the other figures. The relation between the lines in the triangle and the voltages in the figures showing the coils and lamps can be readily seen, as the numbers denoting the voltages are given in both cases.

SELF-INDUCTION IN CIRCUITS.

An ordinary circuit may be considered as a choke coil in which there is a single turn. The action in this case is very similar to that illustrated above with a coil of many turns. The effect of self-induction in a circuit may be most readily understood by some simple diagrams. A current of say 5 amperes is delivered at 100 volts over a circuit of one-fifth of an ohm resistance. The self-induction of the circuit is such that 5 amperes generate a counter E. M. F. of 10 volts. Both continuous and alternating currents are used, and the generator E. M. F. is in each case adjusted to give 100 volts at the load. The load consists, first, of five incandescent lamps. A coil of high self-induction is then added, which increases the current from 5 to 5.1 amperes. One of the lamps is then cut out and replaced by coils of such a self-induction as to give a total of 5 amperes. Then all of the lamps are cut out and coils substituted of such a number as to take 5 amperes at 100 volts. The E. M. F. required on the generator and the resulting drop, or difference of E. M. F., at the dynamo and at the load are given in the diagrams and in the following table:

Fig. 4.

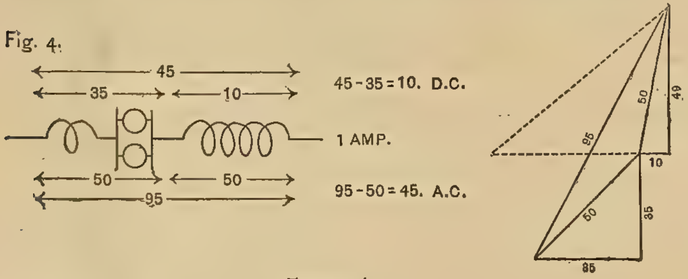


FIGURE 4.

	CONTINUOUS CURRENT.	ALTERNATING CURRENT.			
	FIG. 5.	FIG. 6.	FIG. 7.	FIG. 8.	FIG. 9.
Current in line	5	5	5.1	5	5
Current in lamps	5	5	5	4	0
Current in coils	0	0	1	3	5
E. M. F. on load	100	100	100	100	100
E. M. F. on line	1	10	10	10	10
E. M. F. on generator	101	101.5	102.5	106	110
Drop—total	1	1.5	2.5	6	10

It is to be noted that with exactly the same circuit for supplying five lamps with the same amperes at the same E. M. F.

Fig. 5.

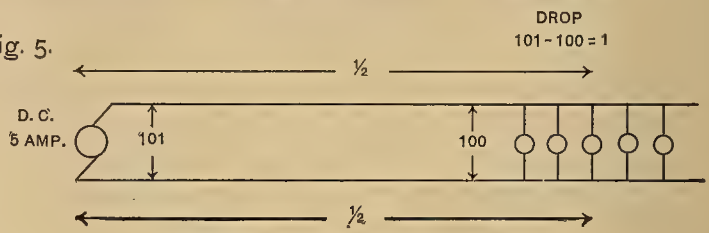


FIGURE 5.—DROP = 101 — 100 = 1.

Fig. 6.

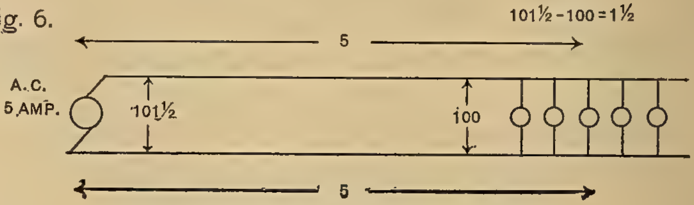


FIGURE 6.—DROP = 101½ -- 100 = 1½.

Fig. 7.

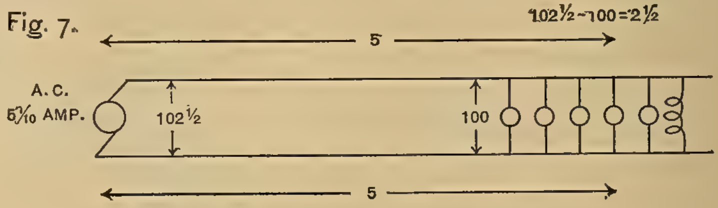


FIGURE 7.—DROP = 102½ — 100 = 2½.

Fig. 8.

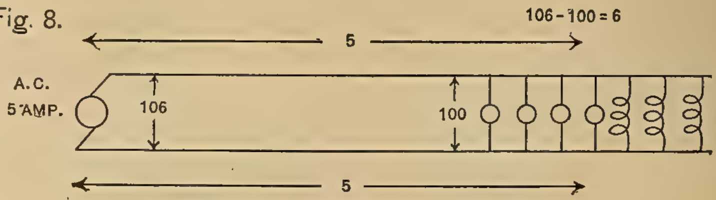


FIGURE 8.—DROP = 106 — 100 = 6.

Fig. 9.

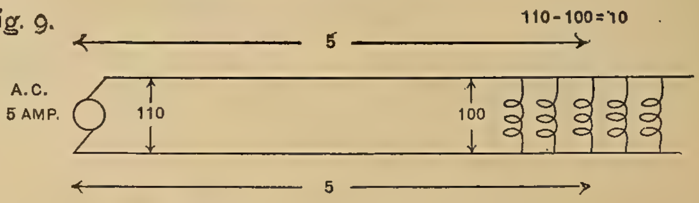


FIGURE 9.—DROP = 110 — 100 — 10.

there is an increase of drop between generator and load when continuous current is replaced by alternating current. This drop is much less than the volts required for sending the alternating current through the line, and it, moreover, increases enormously as the load becomes even slightly inductive. Thus, when the current is increased only 2 per cent. (from 5 to 5.1 amperes, Figs. 6 and 7) by the addition of inductive load to the lamp load, the increase of drop due to self-induction is increased from ½ per cent. to 1½ per cent., or an increase of threefold. When the load consists of four lamps and coils are added in multiple to take a total of 5 amperes from the generator, or the same as that taken by the five lamps, the drop is four times the drop when five lamps alone are in circuit. If the remaining four lamps be replaced by coils, the drop does not increase in proportion, but from 6 to only 10 per cent. The effect, therefore, of a slight self-induction in the load causes a much greater proportional drop than the presence of a large self-induction. A counter E. M. F. of 10 per cent. is not at all likely to occur in a 100-volt line carrying small current. The figures given, however, serve as an illustration of the percentage variations which are possible in other parts of the system.

Fig. 10.

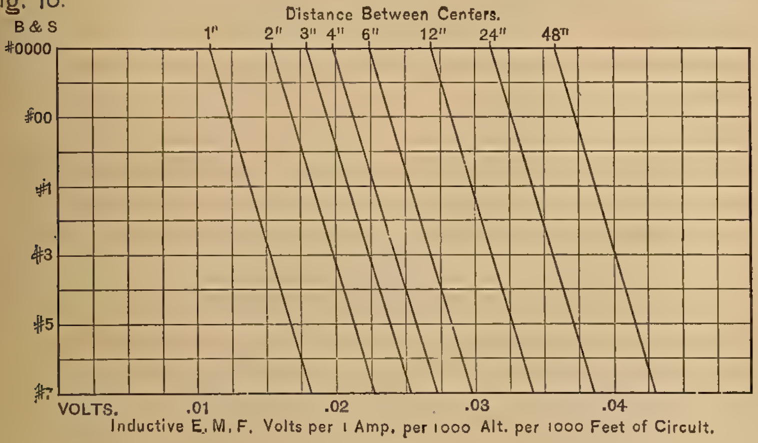


FIGURE 10.

DROP IN CIRCUITS.

The word "drop" in continuous current calculations has a perfectly well defined meaning. In the case of the five lamps which take 5 amperes at 100 volts through a circuit of one-fifth of an ohm, as illustrated in Fig. 5, the drop is: (1) the difference between the E. M. F. at the generator and at the lamps, or 1 volt, which is 1 per cent.; (2) it is the E. M. F. required for sending the current through the line; this is equal to the current multiplied by the resistance, and is the E. M. F. which would be required for sending the current through the line if the load be short circuited; (3) a drop of 1 per cent. means also that the energy lost in the line is 1 per cent. of that delivered by the generator; (4) a loss of 1 per cent. in the line also signifies that the energy delivered is 1 per cent. less than that suplied by the generator.

In alternating current work the same uniformity does not exist; for example, in the experiments with the same five lamps and the same line: (1) the generator pressure was 101½ volts, or 1½ per cent. higher than that of the lamps; (2) the E. M. F. required for sending a current through the line short circuited is 10 volts, or 10 per cent.; (3) the energy lost in wires is C^2 R, or 5 watts, which is 1 per cent. of the energy when five lamps are supplied. If four lamps and low resistance coils are connected to the circuit, the energy delivered is, say, 400 watts and the loss is 1¼ per cent.; (4) if the coils alone are supplied and their combined resistance is equal to that of the circuit, or one-fifth of an ohm, then the losses in load and line are equal and the actual line loss is 50 per cent. The apparent energy at the generator is 550 watts (110 volts and 5 amperes) and the apparent energy delivered is 500 watts (100 volts and 5 amperes), so that the apparent loss is 9 per cent.

It is therefore evident that the several elements commonly referred to as drop or per cent. loss with continuous current are so modified when alternating current is used that it is possible for no two of them to have the same value. Moreover, with alternating current, none of these elements may have the same per cent. value as that for continuous current on the same circuit.

LOSS AND REGULATION.

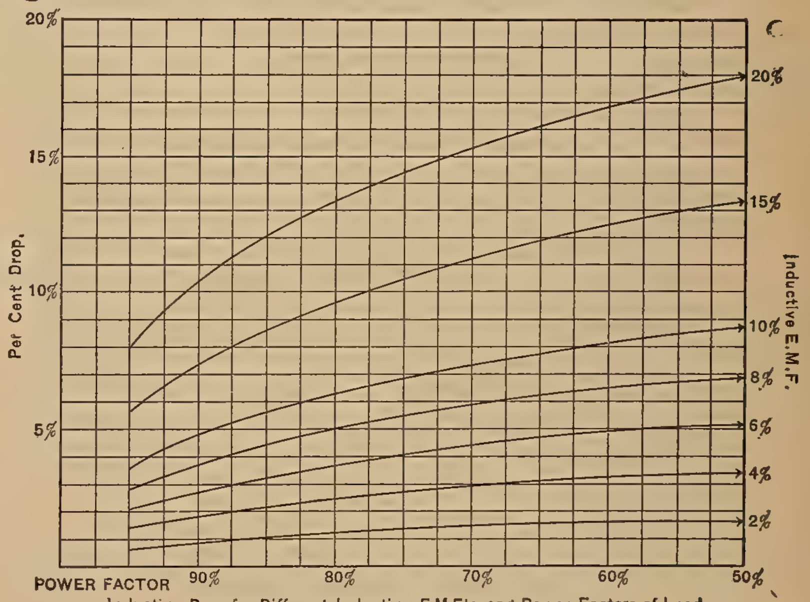
The two vital factors in the line are loss and regulation. The losses are C^2 R, and should be expressed in watts or horsepower, or as a per cent. of the energy delivered to the line. The practical point in regulation is the difference in E. M. F. at the generator and at the load. When these two factors are known, it is generally immaterial what E. M. F. might be required for sending current through a short circuited line. The word "drop" is applied to the difference in E. M. F. between the generator and the load. The regulation is generally expressed in per cent. of generator E. M. F., but in this paper the E. M. F. at the load will be considered 100 per cent., as this is the element to be kept constant while the E. M. F. of the generator is variable, depending upon the load and other elements.

Regulation in a circuit is in general determined by three elements—the resistance, the counter E. M. F. of the circuit and the power factor of the load. The counter E. M. F. of a line depends upon the size of wire and the distance between wires, and it increases directly as the length of the circuit, the current and the alternations. The counter, or inductive, E. M. F. of a line has been calculated for a number of cases, which are likely to occur in practice, and the results are given in Fig. 10.

DROP IN ALTERNATING CIRCUITS.

The drop, or difference of potential between generator terminals and the load terminals, due to the counter E. M. F. of the line, depends, as has been shown, upon the self-induction of the load. The latter is best expressed by a power factor, or a factor by which the product of the amperes and volts, or the apparent energy, must be multiplied to give the true power in watts. The power factor for incandescent lamps is 1.00, as the aparent energy is equal to the true energy. The power factor for transformers loaded with incandescent lamps is usually over .99. The factor for unloaded transformers varies from

Fig. 11.



Inductive Drop for Different Inductive E.M.F.'s and Power Factors of Load.

FIGURE 11.

.50 to .80, and in open magnetic circuit transformers, notably the "hedgehog," the factor may be as low as .05. The drop due to self-induction on the line (which, plus the ohmic drop, will give approximately the total drop), corresponding to various power factors of the load, is given in Figs. 11 and 13. The curves show that if the power factor be 100 per cent., as it is with incandescent lamps, the inductive drops for various counter or inductive E. M. Fs. are .02 per cent. for 2 per cent.; .08 per cent. for 4 per cent.; .18 per cent. for 6 per cent.; .32 per cent. for 8 per cent.; .5 per cent. for 10 per cent.; 1.2 per cent. for 15 per cent., and 2 per cent. for 20 per cent. The curves show that the drop increases very rapidly at first if the power factor becomes less. These relations may be elegantly determined by a simple diagram on section paper ruled in tenths. Draw an arc through a quadrant with a radius of 100. Graduate the horizontal and the vertical scales, beginning with 0 at the center and reaching 100 at the circle. On the horizontal scale find the point corresponding to the power factor of the load, follow up the vertical line to the circle. This line represents the counter E. M. F. of the load and its length read on the vertical scale gives the counter E. M. F. of the load in per cent. of the E. M. F. on the terminals of the load. From the intersection with the arc of the circle proceed horizontally a distance corresponding to the effect of the resistance of the line, i. e., to the E. M. F. required for sending an equal continuous current through the line resistance, expressed in per cent. of the E. M. F. upon the load. From this point proceed upward a distance equal to the counter E. M. F. of the line expressed in per cent. of the E. M. F. on the load.

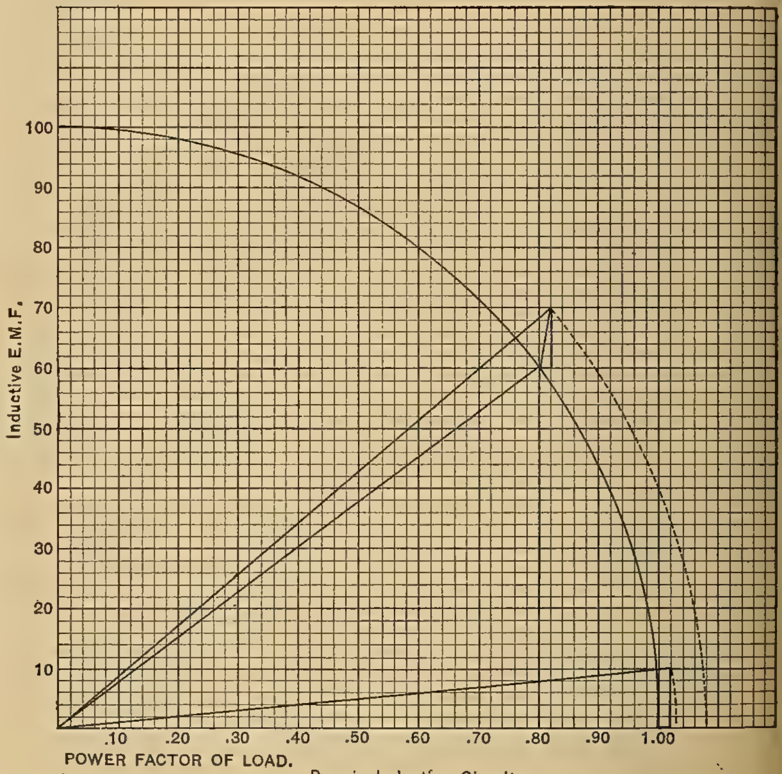
A line from the center to the upper end of this vertical represents, in direction and magnitude, the E. M. F. which must be impressed on the circuit. If from the same center an arc be drawn through this point to the base, the scale divisions on the base between the two arcs measure the total drop caused by the line, in terms of the E. M. F. at the load. This construction is shown in Fig. 12 for two cases. The E. M. F. corresponding to the effect of the resistance of the line, or the "resistance volts," is 2 per cent. in each case, and the counter E. M. F., or the "reactance volts," is taken as 10 per cent. in each case. In one example the power factor is taken as 1.00 or 100 per cent., and in the other case as 0.8 or 80 per cent. The total drop in the first case is seen to be a trifle over 2 per cent., and in the second case about 8 per cent.

SELF-INDUCTION IN TRANSFORMERS, ETC.

Self-induction exists in line, generators, transformers, secondary wiring, and sometimes in the load. In each case the effect of the self-induction upon regulation depends largely upon the self-induction of the total load which it supplies. Thus, the regulation of a generator depends upon the trial self-induction of the line, transformers and load. Again, the regulation of line supplying transformers depends upon the self-induction of the transformers, as well as that of the useful load. The same analysis and diagrams which have been used above in connection with the line will apply to the transformers and approximately to the regulation of the generator.

An ordinary transformer has a primary self-induction and a secondary self-induction and a mutual induction, which become a ready source of very complicated and perplexing analysis when the complete action is described in theoretical terms. Practically, however, the action of the self-induction in the transformer may be expressed in a very simple way, and it is readily seen that this self-induction has a very important bearing upon the regulation of the transformer. The regulation of the transformer is very similar to that of a line, as explained above. If the secondary coil be short circuited, the E. M. F. on the primary may be adjusted so that the normal full load current passes through the apparatus. This E. M. F. is analogous to the E. M. F. required for sending current through a short circuited line, and in ordinary transformers is practically equal to the counter E. M. F. of self-induction, and may be considered equal to it.

Fig. 12.



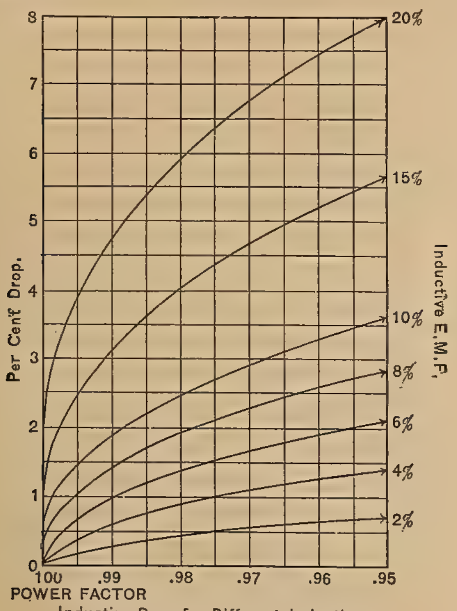
Drop in Inductive Circuits.

FIGURE 12.

A transformer may be taken for experiment in which the E. M. Fs. are 1,000 volts and 100 volts. If 5 volts, or ½ per cent., is required for sending through the primary a continuous current equal to the normal full load current of the transformer, and if a similar E. M. F. in the secondary is ½ a volt. or ½ per cent., then the ohmic loss in the transformer is 1 per cent. and the drop in pressure at the secondary terminals between no load and full load will be 1 per cent. if the self-induction be negligible. If, however, there is a self-induction so that 100 volts, or 10 per cent., is required, at a given frequency, for sending an alternating current of the normal strength through the primary when the secondary is short-circuited, then the drop in pressure is in general greater than 1 per cent., depending principally upon the character of the load. The load may be non-inductive, as lamps, or it may be more or less inductive. The experiments described above, in which a line had the same per cent. ohmic and inductive characteristics as the transformer just described, apply to the transformer as well as to the line. The drop on such a transformer, therefore, may vary from 1½ to 10 per cent. when delivering its rated current. Arc lamps, or fan motors, will produce a very much greater drop than incandescent lamps. The power factor of an alternating current arc lamp varies considerably, but in a number of cases has been found between 85 and 90 per cent. The drop, when incandescent lamps are replaced by arc lamps on the transformer just described, increases from about 1½ to 5 or 6 per cent.

A secondary line, if it carry a large current, may have a counter E. M. F. of several volts. This may not be enough to increase appreciably the drop in the line between the transformer terminals and incandescent lamps. But the transformer, however, delivers current to the secondary circuit and to the lamps, so that the regulation of the transformer may be affected by the self-induction of the secondary circuit. Cases have occurred in which transformers of a very old type possessing high self-induction were supplying very large secondary currents and the resulting drop in the transformers was increased several per cent. For example, a circuit of No. 0000 B. & S. wire supplying 100 amperes to 50-volt lamps at a distance of 100 feet has an ohmic drop of 2 per cent. The constant for counter E. M. F. of this circuit, if the wires be 6 inches apart, is .022. The volts at 16,000 alternations are .022x100x.1x16 equal 3.52, or 7 per cent. of 50 volts. The inductive drop in the line corresponding to 7 per cent. is .25 per cent. The power factor of the aggregate service of the transformer is the second side of a right angle triangle, of which 7 is one side and 100 is the hypotenuse. This is 99.7, which is the power factor of the total load on the transformer. If the inductive E. M. F. in the transformer be 10 per cent., the inductive drop is 1.2 per cent.; if 20 per cent., the inductive drop is 3.4 per cent., and if 30 per cent., the inductive drop is 7 per cent. The aggregate drop in the transformer and secondary circuit in the latter case would be, say, 2 per cent. for ohmic drop in transformer, 2 per cent. ohmic drop in line, 7 per cent. inductive drop in transformer, and .25 per cent. inductive drop in line, or a total of 11.25 per cent. The necessary ohmic drop is 4 per cent. and the inductive drop resulting from self-induction in transformer and line is therefore 7.25 per cent. If the number of alternations be reduced to 7,200, the inductive drop would be reduced from 7.25 per cent. to 1.5 per cent.

Fig. 13.



Inductive Drop for Different Inductive E.M.F's and Power Factors of Load.

FIGURE 13.

MUTUAL INDUCTION.

If two circuits be run on the same pole line they act as a transformer, in which one circuit carrying current may act as a primary and induce E. M. F. in the other as a secondary. If the latter circuit is connected with the same dynamo and is delivering current, its E. M. F. will be slightly raised or slightly lowered by the effects of the first circuit. Conversely, the second circuit will have similar effect upon its neighbor, raising or lowering its pressure by a slight amount. If the two circuits be connected to different dynamos which are running at slightly different speeds, then the E. M. F. induced by one circuit upon the other will sometimes increase and at other times decrease the E. M. F. of the circuit, depending upon whether the two currents at a given moment are flowing in the same or in opposite directions. This fluctuation may cause variations in the intensity of the lights supplied. It is readily detected in the service of some central stations, and is of course most marked at time of full load, as the induction of one circuit upon another depends upon the strength of current carried. The fluctuation due to this action may be readily distinguished from that due to slipping of belts or irregularity in engine speed, as the induction effect is due to the difference in alternations between two machines, and the speeds of the two machines are apt to vary slightly from time to time, giving a gradual variation in the rate of fluctuation of the lamps. The fluctuation due to mutual induction of lines occurs only at the end of the line, and is not observed in the station, while the other causes affect the station lights also. The number of volts E. M. F. set up in one circuit by a parallel circuit depends upon the current, the frequency, the distance which the lines are parallel and upon the relative positions of the four conductors. The distance between wires may be six inches or six feet without affecting the mutual induction, provided the relative positions be unchanged. Several dispositions of circuits are shown in the accompanying Fig. 14, and the number of volts per thousand feet at 7,200 and at 16,000 alternations which are induced in either circuit by one ampere in the other are given in connection with each figure. The number of volts required for producing objectionable flickering in the light depends upon the voltage of the lamps in service, the efficiency at which they are run and the general surroundings in which they are placed, notably the relation of lamps to reflectors, white walls, etc., and the general disposition of the customer.

An E. M. F. of ½ per cent. induced in one circuit by another can in some cases be detected, and usually more than 1 or 2 per cent. will cause objectionable flickering.

METHODS OF REDUCING INDUCTION.

The mutual induction is reduced by bringing the wires in each circuit close together and separating the circuits. The

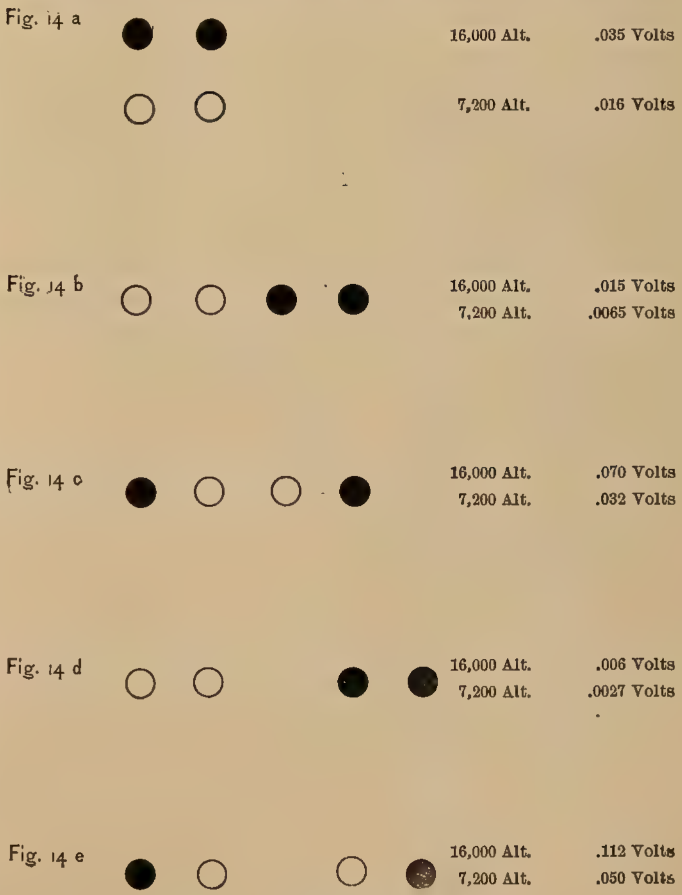


FIGURE 14.—VOLTS IN ONE CIRCUIT INDUCED PER 1000 FEET PER AMPERE IN THE SECOND CIRCUIT.

effect of this mutual induction may be neutralized by crossing one of the lines at its middle point, so that induction in the first half of the line is counteracted by the induction in the second half. It is readily noted that the effect of self-induction in a circuit is reduced as the wires are brought close together, or if each conductor be divided into several wires in multiple and separated. The effect of self-induction is diminished as the number of alternations is reduced. The following points are also to be noted in connection with the inductive drop: If the power factor be nearly 100 per cent., the inductive drop increases as the square of the counter E. M. F. If the E. M. F. of the circuit be increased and the same power be delivered over the same circuit, the per cent. counter E. M. F. decreases as the square of the E. M. F. delivered, and the inductive drop decreases approximately as the fourth power. If the number of alterations be decreased, the counter E. M. F. decreases directly and the inductive drop decreases as the square. The inductive drop at 7,200 alternations is less than one-fourth of that for 16,000 alternations for ordinary power factors.

CAPACITY IN LINES.

The static capacity in ordinary lines is usually small, and its effect is not of importance unless the line be very long or the pressure be very high. The general effect of capacity in the line or of connecting condensers to the line is to lessen the current from the generator which is required for supplying inductive load and to neutralize the drop due to self-induction. The use of condensers for this purpose may lead to very considerable gains in circuits where the self-induction of line or of load becomes considerable. If an inductive circuit or transformer supply current to condensers, the E. M. F. may increase instead of decreasing, as it does with inductive load.

Fig. 15.

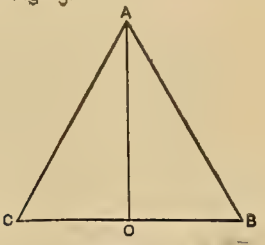


FIGURE 13.

ON POLYPHASE CIRCUITS.

The subjects which have so far been considered apply to single phase as well as to polyphase circuits. The effects of self-induction will be brought to the attention of the electrical engineer much more prominently in connection with polyphase work, however, because the larger alternating current enterprises will be carried out with the polyphase system, and power work involving variable power factors will be a large element in this system. There are, in addition, several problems which relate distinctively to polyphase working. One of these is the most suitable number of phases to be used. The two-phase system and the three-phase system are both in operation, and while it is admitted by the adherents of each system that there is no fundamental difference between them, yet each has specific characteristics giving particular advantages.

The self-induction of a three-phase circuit for transmitting a given amount of power under similar conditions of E. M. F. is the same as that which is incident to the two-phase four-wire circuit, if the same size of wire is used in both cases and the wires of the three-phase circuit are equally distant from one another, and this distance is equal to that between the wires in each phase of the two-phase circuit. This renders the calculation of the drop due to the self-induction of the three-phase circuit quite a simple matter. The loss and the regulation are the same as would be obtained in transmitting half the power at the same power factor over two of the wires of the three-phase circuit. The advantage of the three-phase transmission over single-phase transmission is therefore evident, as the addition of the third wire, involving an increase of 50 per cent. in the weight of the conductor, enables twice the power to be transmitted with the same efficiency and regulation. A corresponding gain is, of course, obtained over the two-phase system, as it is in effect the same as two ordinary single-phase circuits in so far as the efficiency of conductors is concerned.

A further advantage of three instead of four wires is the reduced cost of insulators and line construction, the reduced losses due to leakage and the lessened liability to break-down, resulting from the fewer insulators.

An important point of difference between the two systems is the effect of loading one branch of the system more heavily than the others, as is common in incandescent lighting. One of the statements which remains uncontroverted in Professor Forbes' recent comprehensive and remarkable paper upon the "Electrical Transmission of Power at Niagara Falls" is in reference to the difference of regulation in dynamos for two-phase and for three-phase alternating currents. He gives the result of tests showing that the circuits of a three-phase generator differ greatly in pressure if they are not equally loaded, and states that, having considered these points, the directors of the company determined to reject the three-phase system. These results agree fairly well with tests which I have made. The relative regulation of the two types depends very largely, of course, upon the design of the machines. Other things being equal, the inequality in the voltages on the different phases of a generator, when the circuits are unequally loaded, is much greater in the three-phase than it is in the two-phase type.

If independent regulation of circuits is necessary, one circuit can be given the proper pressure directly from the dynamo and the other circuits may be raised or lowered, as may be required. This involves apparatus for regulating two circuits if the station be operated by the three-phase system, and only one circuit if the two-phase system is in use.

Fig. 16.

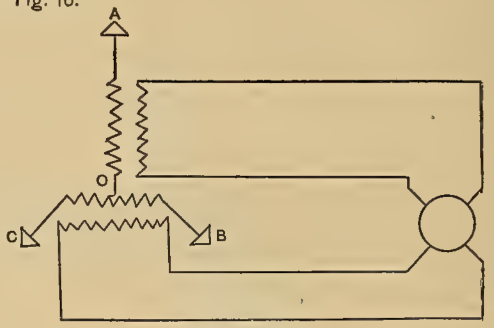


FIGURE 16.

In a system where incandescent lighting is to be a prominent feature, or where load of any kind may be required upon one circuit and not on the other, the two-phase system has, therefore, a decided advantage in station regulation over the three-phase system. Another advantage of a two-phase circuit is that the load is separated into two divisions instead of three divisions, which is in general much simpler. A further advantage of the two-phase is in the reduction of potential for motors. Two transformers are sufficient in the two-phase system, whereas three transformers are commonly used in the three-phase system. The two transformers which would be required for small motors will cost considerably less than the three transformers which would be required on the three-phase system, and the loss in transformation will be much less, as there is not much difference in the cost of small transformers of slightly different sizes, and the large sizes are more efficient. The ease and simplicity of installation is also a gain for the two-phase arrangement.

THE SCOTT SYSTEM.

In considering the advantages of the three-phase system for transmission and of the two-phase system for distribution, it occurred to me that a combination of the two systems might secure the advantages of both in a combined system, and I have worked out a simple and effective method of accomplishing this result. It is well known that if two E. M. Fs. differing in phase be connected in series that the resulting E. M. F. will, in general, differ in value and in phase from either of its components. If two E. M. Fs. differing in phase 90 degrees be connected in series the resultant E. M. F. is represented in direction and magnitude by the hypotenuse of a right angle triangle, of which the two sides are the two component E. M. Fs. Thus, in Fig 15, if $A O$ and $O B$ are two E. M. Fs. at right angles, and these E. M. Fs. be connected in series, the resultant is the line $A B$, of different phase from either of the components. It is a simple matter to so proportion the components that $O B$ is equal to one-half of $A B$, as shown in the diagram. In a similar manner it is readily seen that the same E. M. F., $O A$ may be combined with $O C$, which differs from it by 90 degrees (but is equal and opposite to $O B$) in such a way as to give $A C$ equal to $A B$, but differing in direction. $B O$ and $O C$ added together give $B C$. The E. M. F., $B C$, may therefore be combined with the E. M. F., $A O$, at right angles to it, in such a way as to give additional E. M. Fs., $A B$ and $C A$, which, in connection with $B C$, give three equal E. M. Fs. 120 degrees apart. This is the relation of E. M. Fs. in the three-phase system.

Fig. 17.

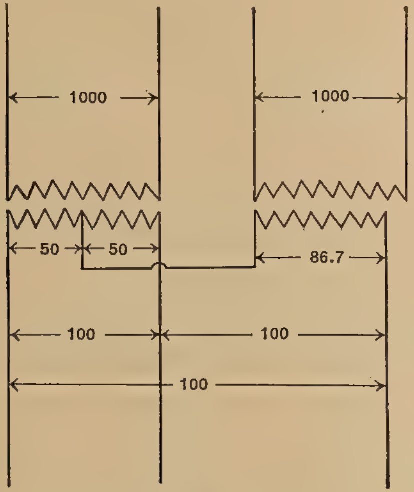


FIGURE 17.

Fig. 18.

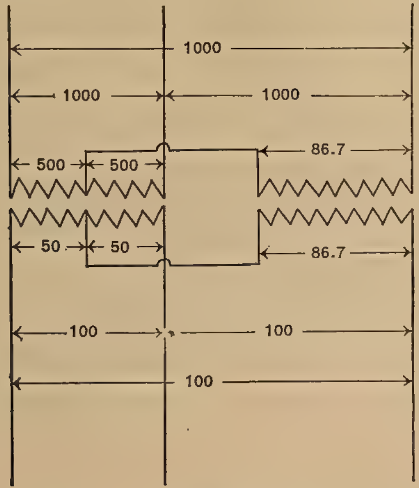


FIGURE 18.

The application of this arrangement to transformers is illustrated in the accompanying Figs. 16 and 17. The primaries of two transformers are connected to a generator giving two-phase current. The secondary E. M. Fs., therefore differ 90 degs. One secondary is made equal to 100 turns and a loop is brought out at its middle point, giving 50 turns at each side. The second secondary has 87 turns, which is approximately equal to 50 multiplied by the square root of 3. One end of the secondary circuit is connected with the middle point of the secondary of the first transformer, as shown, and the three free terminals will then deliver E. M. Fs. differing in phase 120 degrees. If the E. M. F. on each primary be 1,000 volts and on one secondary 100 volts and on the other 87 volts, then the E. M. F. measured between any two secondary terminals will be 100 volts. This three-phase circuit is adapted for operating three-phase motors. In a system of transmission two-phase currents at the generator may be converted into three-phase currents, as shown in Fig. 19, and the windings may be such that the E. M. F. is raised for transmission. The currents are then transmitted by three phases, effecting economy in copper. At the other end of the line a similar arrangement of transformers may be used for converting from the three-phase to the two-phase system. The two-phase currents may then be used for the operation of two-phase motors or the circuits may be independently loaded with lamps, or otherwise. If lamps be placed on the transformer which supplies directly from its two terminals, the transmission is directly from the generator without affecting in any way the other circuit, as the generator terminals are connected directly to the first primaries, and the secondaries of the raising transformer are connected directly to the primaries of the lowering transformer, and the current from this is taken directly to the load. On the other hand, if the other circuit be loaded, the action here will also be on its

Fig 19.

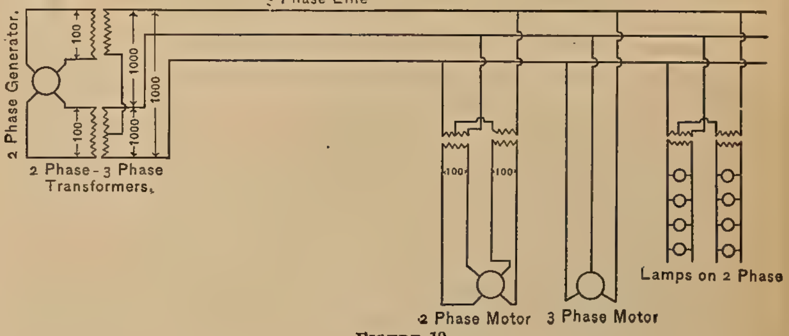
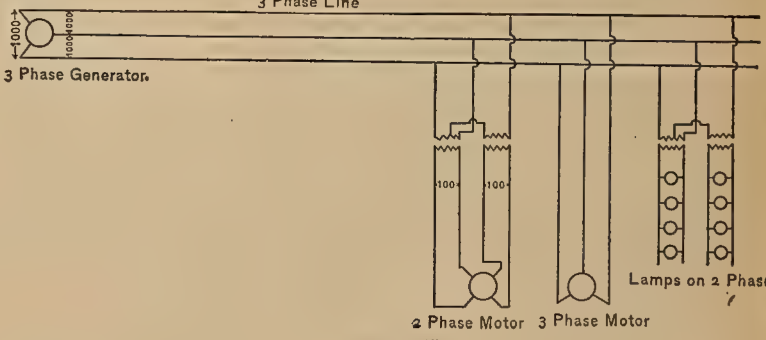


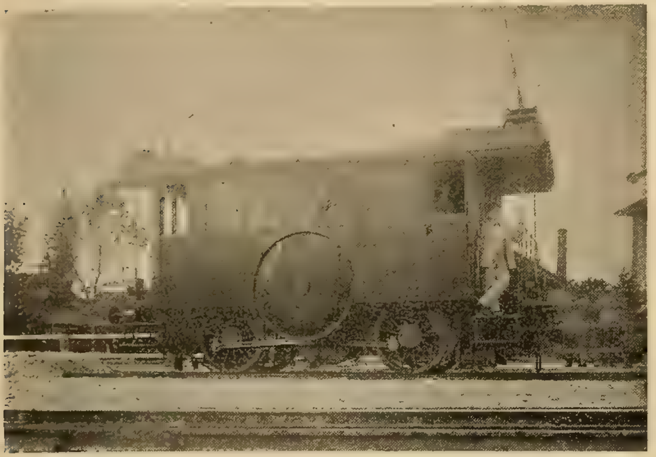
FIGURE 19.

Fig 20.



~~FIGURE 15.~~

own generator circuit without affecting the first. The current from the raising transformer in this circuit passes to the middle of the secondary of the other transformer, where it divides and flows in parallel through the two parts of the coil and two of the lines. As one-half of the current flows through each part of the secondary coil in opposite directions, the self-induction is completely neutralized and the transformers in this circuit are independent of the operation of the other circuit. It is to be noted that under this condition the line E. M. F. delivered by this transformer is only 87 per cent. of that delivered by the first transformer. The lower E. M. F., however, is compensated for by the fact that the current on one side is passed through two of the lines in parallel, thus reducing the resistance of the circuit and compensating for the slightly lower E. M. F.



THE BURGDORF-THUN-BAHN THREE-PHASE LOCOMOTIVE.

The effect upon the regulation of the generator when two-phase circuits at the end of a three-phase transmission line are independently loaded is found, both by theory and test, to be the same that prevails when the load is placed directly upon the corresponding circuit of the generator. A modification of this system is found in the arrangement where the three-phase current is produced in the generator and transmitted over three wires to the reducing transformers. These transformers may be arranged as described for producing two phases (Fig. 20). Loads may be placed upon either of the two-phase circuits, and practically the same regulation in the generator will result that would have resulted if the generator itself had been wound for two phases and one of these circuits loaded. In this way it is possible to place lighting load upon a three-phase generator in two instead of three units, and to avoid the bad regulation in the generator due to unequal loading.

A similar arrangement of two transformers may be used for converting three phases of one potential into three phases of another potential. This arrangement is shown in the accompanying Fig. 18.

The efficiency of two transformers arranged for converting from two-phase to three-phase is reduced below that when working independently on ordinary loads by an insignificant amount. If the efficiency in ordinary working is, say, 97.5 per cent., it would be reduced to 97.4 per cent. in converting from one number of phases to the other.

The Tesla polyphase system, in which the largest electrical enterprises are seeking a realization, adapts itself with marvelous facility not only to all branches of electrical industry, but also by the transformation of its phases to the utilization of three phases for gaining the highest economy in transmission, and of two phases for securing the maximum advantages in distribution.

Transportation

THE BURGDORF-THUN-BAHN POLYPHASE RAILWAY.

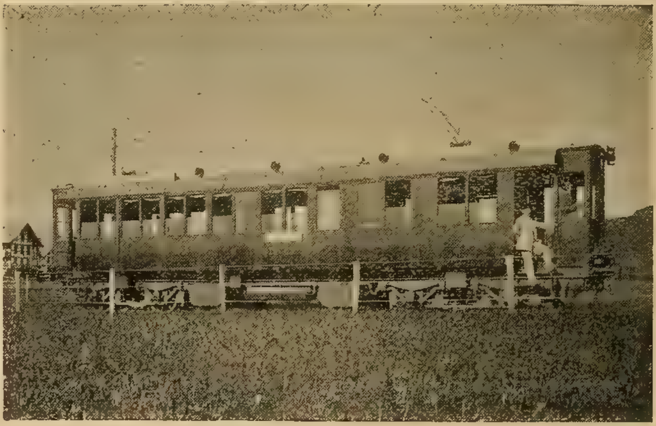
BY ALBERT VAN DER NAILLEN, SR.,
President School of Engineering.

ZERMATT, in Switzerland, is directly connected, through the medium of an electric railway, with the Gornergrat, a most picturesque spot located at an altitude of 10,290 feet in the eternal snow of the Alps — a spot which is believed by all the mountain guides to be the abiding place of that mysterious being called "The Spirit of the Alps," in the existence of which they nourish a most deeply-rooted belief, while holding it in profound and awful reverence.

While looking with much interest at the daring but solid construction of this electric railway on the steep mountain sides and over deep canyons, and noticing the great amount of tourist travel which patronized the road (although the cost is over $3.50 for a ride of only four or five miles), I wondered why it is that in California, where equally charming and interesting spots and scenery exist, we have not the same facilities to offer to the tourists who wish to visit them. We have abundant water power all over the State in all our mountains, enabling cheap transportation, and we might do as is done in Switzerland — let the road lie idle in winter time when the ground is covered with snow and no tourists are "touring."

While thus giving way to reflection, I was approached by a gentleman who, seeing the interest I took in the road, spoke to me and introduced himself as M. Emile Lussy, engineer of and contractor for the building of the road we were inspecting. He told me that this road, like all similar roads in Switzerland, was a paying enterprise, and that the tourists were willing to pay high prices to ride over it, a privilege which they availed themselves of with eagerness, as they supposed that perhaps they would never revisit the scene again. Engineer Luzzy stated that he constructed the mountain road from Viege to Zermatt, the rack and pinion line from Glion Montreux to the rocks of Naye, which ascends to an altitude of 6450 feet in a few miles, and many other mountain lines, all of which pay large dividends.

According to M. Lussy, however, the most interesting electric railway is the recently inaugurated Burgdorf-Thun-Bahn system, which is a standard broad-gauge railway line for passengers and heavy freight, and is operated exclusively by polyphase electric locomotives that are the only ones of their kind in Switzerland, if not in Europe. Engineer Lussy invited me to visit the line as his guest and to convince myself personally not only of the splendid working of these polyphase locomotives, but also of the brilliant promises which they hold out to the near future as a means for effecting the economic transportation of heavy materials on steep grades. Having gladly accepted the kind invitation, we started for Burgdorf, where we met by appointment M. Krahenbuhl, the



THE BURGDORF-THUN-BAHN PASSENGER CAR.

electrical engineer of the road, a most amiable gentleman, who placed himself entirely at our disposal. Moreover, the electric locomotive here illustrated was turned over to us for a trial and inspection, and concerning which M. Krahenbuhl kindly gave us all information desired.

On the Burgdorf-Thun-Bahn electric railway the passenger traffic is handled by an electric car or cars, while freight is carried in standard Swiss goods cars made up into trains and drawn by electric locomotives. The power house, which is illustrated herewith by exterior and interior views, is at Spiez, and the water operating the turbines is taken from the river Kander, which has its source in the lake of Thun high in the mountains. There are four turbines of 900 horsepower each, and these drive through direct-coupling, alternating-current generators, which deliver three-phase current to the step-up transformers at an electromotive force of 4000 volts, whence the three-phase current is delivered to line at 16,000 volts. The length of the road is 35 miles, and the loss on the transmission is six per cent. There are 14 transformers which feed as many different sections of the line with three-phase current at 750 volts, the three sides of the system being afforded in the two overhead trolley wires and the rails.

EXTERIOR OF POWER HOUSE AT KANDER, SWITZERLAND.

Neither trolley wheels nor sliding shoes are used, but instead current is taken into the cars through frames of wire placed transverse to the trolley wires overhead, after the manner common to many European systems, as so fully shown in the illustration. The passenger cars take 240 amperes per phase, which is distributed between four motors, thus showing an average consumption of 60 amperes per motor per phase. I am unable to give any information concerning the power factor of the motors, the starting current, torque or regulation of the generators supplying current for the operation of these passenger and freight motors, but will probably be able to do so in the near future in another article to appear in these columns. When exceedingly heavy loads require two driving cars, they together consume 480 amperes on a grade of 25 per cent, with a load of 25 tons. In addition to the driving motors, each car carries a 100-volt induction motor which drives an air compressor for operating Westinghouse air brakes.

In the freight locomotives, the two axles are moved by two connecting rods which are entirely independent of each other, so that if one should happen to break or become disabled the other would continue in service uninterruptedly. In the middle of the shaft receiving and transmitting the power to the connecting rods is a double clutch which permits the adjustment of a wheel and pinion by a single movement, so that the locomotive may run at the rate of either 12 or 24 miles per hour, or at any intermediate speed, on a 25 per cent. grade, with a load of 50 or 100 tons. The locomotive weighs 30 tons, and is equipped with two motors, each having a rated capacity of 150 horsepower. As before stated, there are two trolley wires, but no trolley; the trolley wheel of the form familiar to Americans is mostly suppressed in Switzerland, for the reasons, they say, that it jumps the wire too easily and requires a fine adjustment of wires around curves. Contact is, therefore, secured by the frames shown on top of the cars, and these frames are of sufficient size to always secure positive contact, even in going around curves where the trolley wires are not central over the track.

These Swiss locomotives are of most excellent construction, as well as of the utmost solidity. On noticing the ease with which they perform their heavy work on grades as steep as 25 per cent., I could not help thinking that they are destined to be indicative of the type of electric locomotive with which the future is to be most familiar.

Personal

E. M. VAN FRANK has resumed the electrical superintendency of the electric-railway division of the Sutter Street Railway Company, San Francisco, which has acquired the Sutro electric railroad.

MRS. L. E. WILLIAMSON has announced the marriage of her daughter Mary Rhoda to Mr. Thomas Hardin Van Frank, on October 19th, at Rialto, Cal. Mr. Van Frank is well known as the manager of the Brooks-Follis Electric Corporation of San Francisco, and the high esteem in which he is so universally held warrants the JOURNAL in extending to him and his accomplished bride most cordial congratulations, not only in its own behalf, but in behalf of the electrical fraternity of the West.

Steam

STEAM ENGINE EFFICIENCY.

IN a paper recently read before the American Society of Mechanical Engineers by Prof. Thurston, a table is given showing the best economy attained up to the present year with different types of steam engines. The best performance has been from one of the Corliss type using steam at 62 pounds pressure and developing an indicated horsepower on 17.5 pounds of water per hour. A Leavitt pumping compound engine using steam at 135 pounds, developed a horsepower on 12.16 pounds of water per hour, while a high-speed McIntosh & Seymour compound engine has developed an indicated horsepower on 12.76 pounds of steam per hour, the initial pressure being 125 pounds. The best showing for a triple-expansion engine was in the case of a Snow pumping engine using steam at 156 pounds pressure, and developing a horsepower on 11.26 pounds of water per hour. Of quadruple-expansion engines the best record is that of a Hall & Treat engine using steam at 400 pounds pressure and developing a horsepower on 9.67 pounds of steam per hour.

INTERIOR OF POWER HOUSE AT KANDER, SWITZERLAND.

THE JOURNAL OF
ELECTRICITY, POWER AND GAS
Devoted to the Conversion, Transmission, and Distribution of Energy.

Conducted by GEO. P. LOW.

Official Organ of the Pacific Coast Electric Transmission Association.

Yearly subscription: Domestic, $1.00; Foreign, $1.50, postage paid.

Entered as second-class matter at the San Francisco Post Office, August 15, 1899.

Entered as *The Electrical Journal*, July, 1895. Entry changed to *The Journal of Electricity*, September, 1895.

Published monthly at 320 California Street, San Francisco, Cal.
Address remittances and communications to
315 CHERRY STREET, [Telephone, "Pine 76"] SAN FRANCISCO, CAL.

VOLUME VIII DECEMBER, 1899 NUMBER 6

For Table of Contents see Page X.

EDITORIAL.

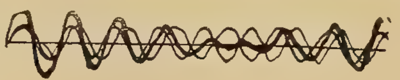
PHILOSOPHY OF SYNCHRONIZING ALTERNATORS.

The word "synchronize" implies agreement in points of time; hence, when used in an electrical sense, is equally applicable to both the frequency and the phase relation of alternating-current wave forms. To "synchronize" alternators indicates that they have been brought not only to an equal frequency, but that they have as well been brought to that condition where their phase relations are both identical and simultaneous; that is, that their phases are "in step," meaning thereby, that they give a maximum electromotive force of the same sign at the same instant, and that they continue to be thus in step for an appreciable period of time. Alternators may, therefore, have the same frequency but be out of step; or they may be in step at a given instant, but be out of frequency; but when they have been brought to synchronism, it is understood that they are both in step as to phase relations as well as of equal frequency. The application of these terms in that which follows should now be clear.

When alternators are to be coupled in parallel, they are brought to conditions of equal frequency, of equal phase relations—or in step—and of equal voltage, though the latter is less important than either of the other two conditions. If an unattached single or polyphase alternator have its fields excited and its armature connected up to another similar type of alternator which is being run as a generator, the unattached alternator will exert a very powerful tendency to run with the generator, provided it has been first brought up in step with, and of equal frequency to, the generator. A considerable load may be put upon the motor (for such the unattached alternator becomes) and the two machines will keep in synchronism, for such is their inherent characteristic.

As with direct-current dynamos, the possibility of running alternators in parallel is due to their reversability, or, specifically, to their ability to act as synchronous motors precisely as just described, for if one machine, by reason of mechanical or electrical disturbances, tends to slow up, the other will force current into it, running it as a motor and increasing its speed until it hurries it up into synchronism again. So strong is this effect that if the machines are thrown in parallel when they are in direct opposition of phase, they will right themselves in time, provided they are of the same frequency, or nearly so; but this experiment is sometimes a very trying one, as will be shown.

Messrs. Gardner and Howgrave-Graham,[*] have compared two alternators which are to be thrown in parallel to two pendulums of slightly different lengths. If these pendulums are started to swing in phase, or in step, they will, after a short time, get out of step until when one is swinging in one direction, the other will swing in the other direction, and, similarly, they will consume the same time to get back into step as was required to get out of step. Two alternators will behave in exactly the same way when they are connected in series and not in synchronism. At one moment they will supply a voltage equal to the algebraic sum of their voltages, and the resultant voltage will be a maximum, and, as time goes on, they will oppose each other, and the algebraic sum will be the arithmetical difference, giving a minimum resultant voltage.



In this figure, the two curves represented by light lines illustrate the curves of two alternators slightly out of synchronism. The heavy line shows the curve that is obtained by taking the algebraic sum of the ordinates of the two light-faced curves, and from these it will be seen that the resultant voltage grows and then dies away. The more nearly the machines are in synchronism the slower the fluctuations will be. This effect is very important, as it is made use of in most synchronizing apparatus.

⁂

Assume now, that two machines are up to proper frequency, but are not in step. If they are thrown in parallel when in this condition, a current of greater or less amperage will oscillate between them, which, if their phases are in direct opposition, may be enormous, especially in armatures without iron, in which case the armatures will probably be destroyed. This enormous rush of current will, if the armatures stand the strains caused by it, slow up one of them a little, causing their frequencies to differ, when they will begin a see-sawing which will eventually bring them into synchronism through the motor actions referred to. It will probably take several seconds to accomplish this, during which the voltage of the distribution circuits will be more or less seriously disturbed—so much so that it is sometimes possible for synchronous motors operated therefrom to drop out of step, several such occurrences being sufficient to paralyze the whole system. Alternators having iron-clad armatures, and especially those with big teeth, are of sufficiently high induction to limit the enormous inrush of current caused by synchronizing machines that are seriously out of step; but commercially, alternators which are not in step and not in synchronism—*i. e.:* of equal frequency—are not thrown in parallel unless by accident, for the very cogent reason given.

---

[*] Transactions Institution of Electrical Engineers, London, March 22, 1899.

Regarding frequencies, Steinmitz showed, as early as 1894,* that alternators with a frequency as high as 125 cycles and as low as 25 cycles per second would, when properly designed, work perfectly in parallel; and, moreover, he found that the self-induction of machines within the limits of well-designed alternators has nothing to do with the success of synchronous running, as armatures of low and high self-induction run in parallel with perfect success.

⁂

The synchronizing of alternators has now been reduced to a comparatively simple mechanical operation, and even the difficulties which attend the parallel operation of steam-driven, direct-coupled alternators have at last found to be chargeable to the engine rather than to the alternator. Under ordinary conditions the problem of synchronizing slow-speed, direct-coupled, steam-driven generators is one that any steam engine builder can solve by regulating the retarding action of the engine governor, and this retardation need not ordinarily be so great as to seriously affect the speed control. Such synchronizing, when under improper conditions, is apt to be accompanied by periodic cross currents and periodic variations of the cut-offs in both engines, but the cases wherein it becomes very difficult to obtain stable parallel operation will be found to be rare. Of course, all difficulties in synchronizing alternators are greatly reduced by increases of speed, and in water power plants in particular, where high speed and an even angular velocity are combined, the parallel operation of alternators is a process of the utmost reliability.

HIGH VOLTAGE TRANSMISSION LIMITATIONS.

Electric power transmissions for distances approaching 150 miles are projected in several portions of the West and some of these enterprises have passed so far beyond the stages of promotion that they are already looked upon as being all but literal realities. California seems destined to continue to lead the world in electric power transmission, and it already does so in pioneership, in distance of transmission, and in the use of the highest commercially-successful line voltages. But these new transmissions are of such great length that the cost of line construction is bound to compel the making of most strenuous efforts toward the utilization of still higher voltages than any yet found in commercial practice, in view of which the industry must feel grateful to *Cassier's Magazine* for the publication of an article in its last issue on the "Practical Limitations of Electric Power Transmission." In this valued contribution, Dr. Louis Bell gives impartial and conservative discussion of the questions involved, in which the opinion is expressed that the difficulties attending the use of potentials between 50,000 and 60,000 volts are perhaps prohibitive.

Dr. Bell truly points out that during the past half-dozen years a great fund of practical information has accumulated concerning transmission at high voltage, and that within a wide range, engineers are now treading on no uncertain ground. Conservative voltages have been steadily creeping upward, and experiment has grown into standard practice until the art has been revolutionized. The first great step was taken when engineers squarely faced the problem of dealing with alternating currents that demanded that they be treated with respect, and came to a realizing sense that the proper place to insulate a high-tension wire was at its supports. It very soon became evident that when once past pressures which can be handled with impunity, further increases in voltage involved no additional danger and were practically limited only by existing conditions as to insulating the apparatus. Given adequate insulation, the line problem was, is, and ever will be easy.

The upshot of the matter has been that the 1000-volt plants common ten years ago, are now practically obsolete; while for transmission of even a few miles a line pressure of 10,000 volts is generally used, and even local distributions are ordinarily run at or close to 2500 volts. At the present time one may fairly call 10,000 volts the standard working pressure for transmission purposes, and its use has been proven beyond question to be in every way as reliable as if much lower potentials were to be used. As the voltage rises beyond this figure no alarming phenomena appear for some time. The danger of puncturing insulators increases, but this merely makes it necessary to thoroughly test them and to provide a suitable factor of safety. Moreover, raising and lowering transformers are not materially more difficult and expensive to build and insulate. The "striking distance," however, rises noticeably, but its increase is a matter that is not yet troublesome except as it may indicate resonance, to which is frequently due the considerable increase in striking distance often noticed on long lines, which sometimes may become annoying, although seldom serious.

Aside from resonance, little occurs that is noteworthy as the pressure is further raised until it approaches 20,000 volts. At about that point the lines begin to be luminous at night—at first appearing as a hazy bluish film of light at the surface of the wires, with faint brushes at points such as the tips of tie wires. Thus results a static discharge into and through the air along the high-voltage wires. The energy is leaking wherever it gets a chance—from the wires, across the oil in the transformers, and from every point and edge along the line. At 20,000 volts this static leakage amounts to very little as a matter of loss in energy; in fact, it is merely apparent. As the voltage rises above this figure, the discharge becomes more marked until at 40,000 volts a perceptible, though not material, amount of energy is devoted to keeping up this action. It is exactly the same sort of thing that one sees in a darkened room about the wires leading from a

---

**The Electrical World*, Vol. XXIII, page 285, March 3, 1894.

powerful Ruhmkorff coil, except that it is on a colossal scale. Add 10,000 or 15,000 volts more to the line and the situation becomes serious, for the energy streams off in amounts rapidly growing graver, and under the terrific strain the air tends to become weaker and weaker as an insulator.

At this point two courses are open: either to increase the distance between the wires or to insulate them. The latter course probably can not afford permanent relief and the former mitigates the evil but does not altogether cure it. Hence, although one plant is being operated in Utah at 40,000 volts, it seems that this point nears a limitation inherent in air as the medium in which aerial lines work. Between 50,000 and 60,000 volts the case grows very serious, "perhaps prohibitively so," states Dr. Bell, so long as transmission lines are run in air

Operation at these or higher voltages, if at all possible, appears to necessitate a consideration of questions as to whether the lines shall be run underground in expensive cables, or under or above ground in oil tubes. Possibly the latter may be accomplished when some one finds a cheap non-conductor that will hold oil successfully, but even then resonance is to be dreaded. Going underground or into tubes means adding capacity to the system and this means a chance of hitting resonance of lower harmonics, or even the fundamental. Very formidable resonance has been detected on one line having some underground connections, and electrical transmission interests shall hear more of it, although it is worth noting that increased voltage does not necessarily imply increased danger of resonance. In point of voltage, then, trouble must be provided against as 40,000 volts is approached, even in good climate; and, furthermore, the placing of lines underground must be very cautiously done.

Thus is given, almost verbatim, the opinions held by one of the best-known electrical engineers of America on a subject fraught with great concern to transmission interests. Especially is this so to those of California, which is detined to be the scene of action of the highest potentials and the longest distance transmissions of the world. Here the difficulties which are pointed out must be met and overcome, for not many decades will pass before the Sierras will be studded with power houses from the mountain streams of the Southern California Water Company in San Diego, to the McCloud River in Sikiyou, whence transmissions will be run to all cities, towns and industrial centers, and these transmissions will be interlinked as intimately as are those of southern California today. Not only will service interruptions thus be prevented, but the transmissions will be operated at highest possible voltages and over greatest distances within the bounds of commercial limitations. Toward these conclusions all climatic, physical and political conditions trend.

M. Chevalet has muffled the noise of large gas engine exhausts by connecting the exhaust to a small scrubber. With gas engines the scrubber is not supplied with any liquid, but with petroleum engines the escaping products are regularly washed so as to recover the oil and get rid of the smell.

Gas

INDUSTRIAL GAS.—IX.

BY FRANK H. BATES.

THE JUNKER CALORIMETER. Whenever fuel is employed in any quantity, whether gaseous, liquid or solid, an exact knowledge of its calorific power is required in order to decide upon its cost. Likewise the heat energy required for a given work can only be determined by measurement of the fuel when its calorific power is known. For instance, in making a test of a gas engine, a reported consumption of a certain number of cubic feet of city gas, or producer gas, per horsepower-hour, unaccompanied by other data, would be indefinite, since the quality of the gas might vary within a wide range, giving a greater or less consumption per horsepower at different times. It is evident then, that, in order to convey an accurate idea of quantity when dealing with heat, whatever the source, it is necessary to base all computations upon the number of heat units, when comparative consumptions and costs are readily estimated.

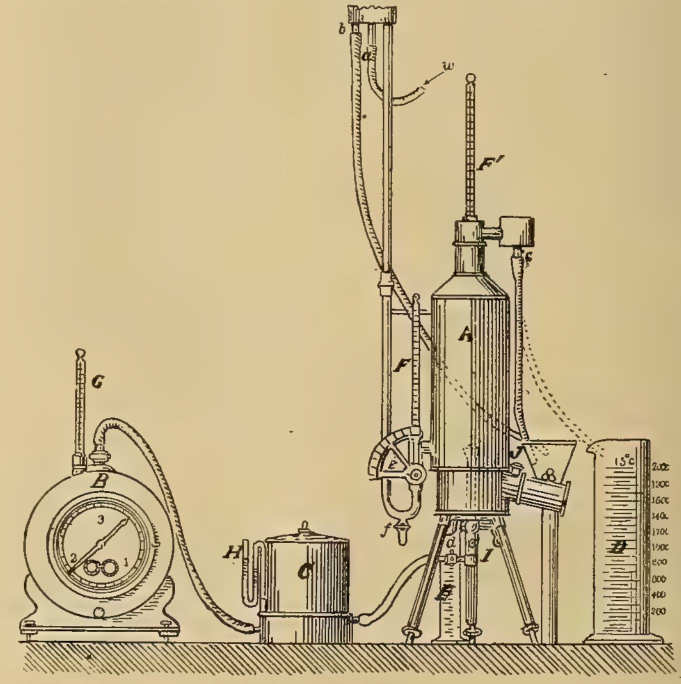


FIGURE 27.

Description of the Junker calorimeter. This instrument is especially suited to the continuous determination of the calorific power of a gas or liquid, since it not only serves to show the heat value of a product at any given time, but additionally, all the fluctuations occurring at various stages of a process.

The apparatus consists of:

A calorimeter proper, designated by A, Figure 27, with a Bunsen burner, I, which projects into the combustion chamber;

A pressure regulator, C, for regulating the pressure of the inflowing gas (thus avoiding the fluctuations in pressure of the gas source), with a small U-tube to indicate the pressure of the gas in inches of water;

An accurate gas meter, B, graduated in litres* and provided with an opening for the insertion, by means of a rubber stopper, of a thermometer for registering the temperature of the outflowing gas. A wet or dry meter may be used according to conditions and preference;

A collecting jar, D, graduated up to 2000 cubic centimeters, for collecting and making measurement of the water used;

A collecting jar, E, graduated up to 100 cubic centimeters, for collecting and making measurement of the water of condensation;

A set of thermometers consisting of three graduated up to 50° C. for the measurement of the temperatures of the air of the room, of the gas at the meter (thermometer G) and of the products of combustion issuing from the calorimeter (thermometer at J); also two standard thermometers (F and F′) graduated in tenths of degrees and scaled up to 50° C., for the measurement of the temperatures of the inflowing cold and outflowing heated water of the calorimeter. These thermometers should be provided with adjustable reading glasses;

Rubber stoppers for holding and fitting the thermometers in their respective positions, and rubber tubing for making all connections.

The calorimeter proper consists of a copper vessel, the copper sheeting employed in its construction being as thin as compatible with strength, mounted on adjustable legs, provided with a combustion chamber in which the fuel is burned (if gaseous fuel a regulator insures constant pressure), the products of combustion passing upwards and downwards through the outer compartment of the calorimeter in an opposite direction to the ascending water (which is under a constant head), giving up in transit all the heat resulting from the combustion. The detailed view, Figure 28, makes the construction clear. In the combustion chamber 28, is inserted the Bunsen burner 27, proper adjustment as to the height being made by sliding the carrier 25 along the fixed rod 26 and binding by the set-screw shown. The rod 26 is provided with a flat surface in the rear of the proper position of the burner, so that, on bringing up the set-screw, the burner will be located centrally with reference to the combustion chamber. The heated products of combustion pass to the roof of the chamber and then downward through the network of tubes 30 (shown in both the views A and A′), finally collecting in the cylindrical portion 31, and then passing through the damper 33 of the chimney 32 into the atmosphere. Provision is made for the entrance of water at 1, from where it passes into the small compartment 2 (over which is placed the lid as shown), perforated with small holes which are screened to prevent the passage of foreign matter. Through these perforations of compartment 2 it passes into chamber 3, connected by the piping 6, with a union at 7, to the regulating-cock 9, the pointer of which, together with the graduated arc, is best shown in view A″. Sufficient water should be supplied to chamber 3 to maintain a constant overflow from the upper edge into the surrounding chamber 4, from which it may escape by rubber tube connections from the nipple 5. This provides a constant head of water on the regulating-cock 9, insuring the maintenance of the same rate of flow through the instrument when the valve has once been adjusted to suit the requirements of the test.

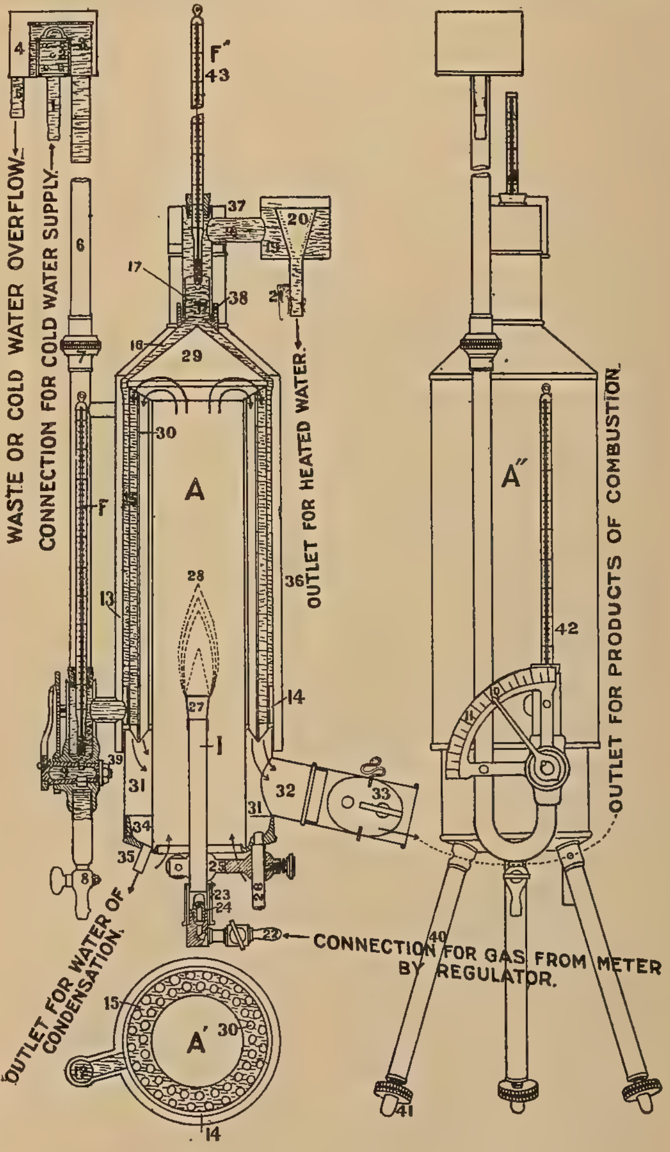

4
WASTE OR COLD WATER OVERFLOW.
CONNECTION FOR COLD WATER SUPPLY.
F′
43
6
7
37
20
19
17
38
21
16
29
OUTLET FOR HEATED WATER.
30
A
F
28
36
13
14
27
1
39
31
32
33
31
34
35
8
25
26
23
24
22
OUTLET FOR WATER OF CONDENSATION.
CONNECTION FOR GAS FROM METER BY REGULATOR.
40
15
A′
30
14
A″
42
OUTLET FOR PRODUCTS OF COMBUSTION.
41

FIGURE 29

The course of the water through the calorimeter is as follows: From the regulating-cock 9 it flows around the bulb of the thermometer F through the horizontal conduit into the chamber 15 enclosing the tubes, upwards by 16, around the roof of the combustion chamber, through the baffle-plates 17, where it is thoroughly mixed, then around the bulb of the thermometer F′ and through the arm 18, to the compartment 19, overflowing into the exit pipe 20. A jacket of air, 13, is placed around the entire body of water to prevent loss of heat by radiation. A small opening at the bottom edge serves to relieve the pressure due to the expansion of the enclosed air, but being the only one does not give rise to a circulation of the air.* The nipple 35 serves to drain any water resulting from the condensation of the products of combustion.

---

*In this description all the measurements are made by the French system; the English system may be substituted, however, using a meter graduated in cubic feet, thermometers in Fahrenheit degrees, and graduates in cubic inches.

The pressure regulator is shown in detail in Figure 29. The gas passes from the meter by rubber tubing to nipple A of the regulator, into the lower portion of the central channel B, up by the open valve C, and into the main chamber E. The exit to the burner is by pipe F. Weights are provided with which to vary the pressure, and with a central hole to fit the stem I, over which they are placed, resting on the nut K, made fast to both the shell and stem. The compartment G is partially filled with water to form a seal for the gas. The valve C is actuated by the stem I, which, in rising with the shell, checks the admission of gas until the pressure is slightly reduced by the outflow of gas through pipe F to the burner. With a fairly uniform pressure of gas at the source, the regulator may be adjusted to a nicety, the shell varying its position within a very small range. A regulator is required since the flow of gas to the burner must be maintained at a uniform rate to secure accurate results. The pressure of the gas in the burner is shown by the difference of level of the water in the two limbs of the U-tube (H, Figure 27). If preferable, a dry pressure regulator may be employed, such a one being shown in Figure 30.

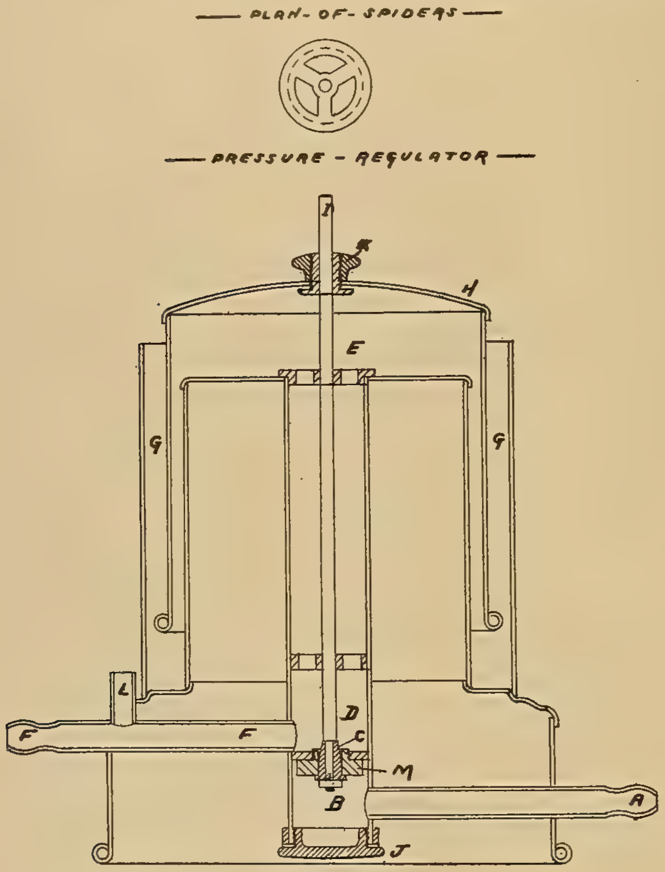


FIGURE 29.

The Bunsen burner, with regulating-cock removed, is shown in the sectional view, Figure 31. The cap A on the upper end is detachable, not being required with some gases. It is advisable to employ a small screen to fit in the cap A at about the line B, to prevent the gases taking fire below at the air-valve C, which will sometimes occur with gases requiring a considerable opening of the valve; that is, considerable air for their combustion. This occurring, will put out the light at the top of the burner, making necessary a repitition of the test.

Arrangement of parts. Place the instruments so as to render easy the rapid reading of the thermometers. Level by means of the adjusting screws, both the gas meter and the calorimeter. Make up the connections as shown by Figure 27, and with the thermometers G for measuring the temperature of the gas leaving the meter (when using a wet meter the requisite water should be poured in some little time previous to making the test so that it may acquire the temperature of the room), F and F′ for the temperatures of the cold inflowing and heated outflowing water of the calorimeter, and at J for the exhausting products of combustion, and a thermometer in the room as well (in close proximity to the apparatus) for registering the temperature of the air of the room (giving the temperature of the air entering into combination with the gas in burning).

If possible, have an overhead tank for water of a size suited to the duration of the test, in order to have the temperature of the entering water and the air of the room the same, thus avoiding the necessity for making any correction for air as would probably be the case if the water were taken from an outside source. Keep all temperatures as constant as possible during the tests, and notice that no draft strikes the chimney of the calorimeter. When the tests are of short duration it would be advisable to have one or two assistants in order that simultaneous readings may be taken in quick succession. However taken, all readings should be made at regular intervals in order that a fair average may be obtained.

Have piping from the gas source terminate near the meter with a valve and nipple, connecting the nipple by rubber tubing to the inlet of the meter.

Connect the water inlet *a*, by tubing to a similar pipe with valve and nipple, from the water supply.

Attach a piece of tubing to the cold-water overflow *b*, to reach handily to the drain, which should be fitted with a glass funnel to show the outflowing water from the position of the operator. A drain should be provided close to the calorimeter.

Attach a piece of tubing to the heated water outlet *c*, of a length such as will permit of its end being placed alternately in the drain and graduate D, which should be placed close by, with the graduations outward, that they may be noted.

The small graduate E is placed beneath the nipple *d*, for the collection of the water of condensation.

The burner I is inserted within the combustion chamber about 12 centimeters (4.7 inches), the exact distance depending on conditions.

---

*The only means by which loss of heat could take place would be by either conduction or convection through the air to the outer surface from which to radiate. Conduction will take place only to a slight degree, air being a very poor carrier; and convection is out of the question, there being no circulation. Furthermore, the outer surface is highly polished, reducing radiation to a minimum. We may therefore consider, for all practical purposes, that no loss of heat takes place.

The drip, or bleeder, *f*, provides for the drainage of the water column and is, consequently, only used when taking the instrument down, being closed during operation.

The flue of the calorimeter chimney is opened to suit prevailing conditions, generally not requiring any particular adjustment.

Operation. 1. Test the calorimeter for leakage by opening the water-supply valve and regulating-cock *e*, causing the water to shortly issue from the outlet *c*. After a brief wait, if no water drips from the drain *d*, one is certain that there is no leakage.

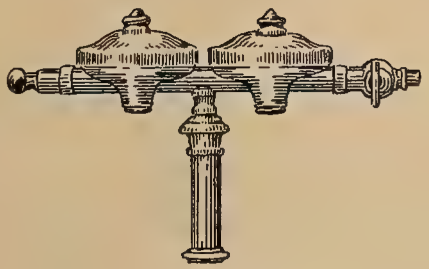
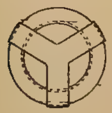
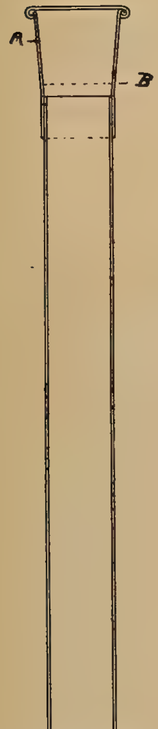


FIGURE 30.





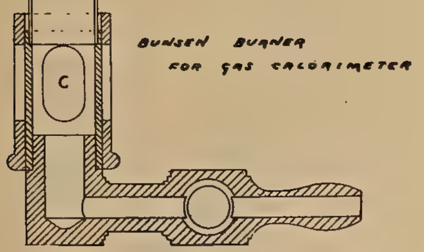


FIGURE 31.

2. By means of the regulating-cock *e*, adjust the flow of water so as to cause it to issue from *c* at a rate that will about fill the large graduate (2000 cubic centimeters capacity) in five minutes.

3. Adjust the valve on the water supply so as to admit through the cold-water inlet *a* sufficient to cause a slight but constant overflow from the cold-water overflow *b*, seen in the glass funnel into which the connecting tube drains, thus insuring a constant head on the regulating-cock *e*.

4. Pour enough water in by the top of the regulator C to form a water seal when the cover is at its highest position. Also pour a little water in the U-column H.

5. Adjust the valve on gas supply to admit a small flow to the meter, and then adjust the Bunsen burner regulating-cock to give a flame such as will maintain a difference in the temperatures of the incoming and outgoing water of about 10° C. The precaution must be taken to light the burner outside the calorimeter. The pressure regulator should be weighted to maintain the proper pressure of gas in the burner.

We now have the following order of operation:

Gas is passing from the source of supply through the meter, around the bulb of the thermometer G (Figure 27), by the meter outlet through the rubber tube connection to the regulator C (the gas pressure being indicated in inches of water on the limbs of the U-tube H), through the regulator outlet by rubber tube connection to the Bunsen burner I, through the burner valve to the tip where it is burned in the combustion chamber of the calorimeter A. The products of combustion pass upwards to the roof and then downwards through the tubes, around which the cold water is ascending, giving up to the latter in the passage all the heat generated by the combustion, then issuing from the outlet or chimney immediately after having passed the bulb of the thermometer J. Water is passing from the source of supply to the cold-water inlet *a* in sufficient quantity to give a constant head at the regulating-cock *e*, from which it passes around the bulb of the thermometer F just previous to entering the calorimeter, through which it ascends, absorbing in the passage the heat of the down-flowing products of combustion. Thoroughly mixed by the baffle-plates in the upper portion of the calorimeter, it passes around the bulb of the thermometer F′ and immediately through the heated water outlet *c* to the drain or graduate.

Special hints. Caution should be exercised to prevent the water in the calorimeter becoming too hot, as it would expand the mercury in the thermometers to such an extent as to break them. When the nature of the gas does readily admit of securing the proper difference in the temperatures of the ingoing and outgoing water by a regulation of the flow of gas, a slight adjustment of rate of the water flow will effect the desired result.

Always light the Bunsen burner outside the calorimeter, and only insert in the combustion chamber after allowing a sufficient lapse of time to permit of any gases collected therein to pass out, otherwise a severe explosion may result.

Regarding the adjustment of the air-valve on the Bunsen burner, see that a sufficient quantity of air is admitted to render the combustion as smokeless (flame showing as little carbon as possible) or as complete as possible. With producer gas or gas of low calorific power, no air whatever need be admitted to the burner, whereas with gas of high calorific power, as coal gas, considerable is required.

The entire consumption of water need not exceed three liters per minute.

The consumption of gas will be in accordance with its calorific power, making it impossible to direct the use of a certain flow of gas or certain length of flame at the burner. The extreme capacity of the calorimeter is 2500 calories per hour. It is advisable to operate with a rate such as will give an absorption of about 1200 calories per hour.

(Continuation in next number.)

THE SUN AS A SOURCE OF ENERGY.*

BY DR. W. BORCHERS.

ALL natural energy which man possesses in the present condition of the earth's crust and which puts and keeps in motion the action of machinery, mechanisms, and living organisms, is derived directly or indirectly from the radiating energy of the sun. The various forms of such energy may be converted more or less easily one into the other, and among these forms are distinguished (1) radiating energy, visible light and invisible rays ascertainable by their chemical or electrical effects; (2) heat; (3) mechanical energy; (4) electrical energy; (5) chemical energy. The most fugutive of these is radiating energy.

Note what becomes of this radiating energy upon striking the earth. One part of it is converted at once into heat in which form it penetrates into the earth at a moderate depth, doing work which is partly mechanical, partly chemical. The mechanical work consists chiefly in evaporating and lifting water. If there be assumed a mean rainfall of one metre (39.37 inches) and the height of the clouds at 3000 metres (9842.5 feet), the work done by the sun equals 661,560,000,000 horsepower per second. Only a vanishingly small part of this energy can be utilized by man, but today the attempt is made to sieze it wherever it can possibly be caught.

Not less noticeable a part of the sun's energy is directly or indirectly converted into chemical energy. Through the reaction taking place in the bodies of plants, and simply expressed by the formula $6CO_2 + 5H_2O = C_6H_{10}O_5 + 6C_2$, are obtained wood and other plant fibers, starches and other similar substances suitable for creating heat. It has been proved that about one kilogramme (2.2 pounds) of wood can be made to grow annually on one square metre of suitable soil. From one square kilometre of wood or farm land may be obtained 1000 tons of vegetable matter with a thermal value of 4000 calories per kilogram (7108 British thermal units per pound), which is equivalent to about 700 horsepower delivered continuously. Assuming but a very small proportion of the entire terrestrial surface of 136,038,872 square

---

*From "Electrolytic Processes in Industrial Operations," in *The Engineering Magazine*, Vol. XVIII, page 389, December, 1899; abstract.

TEMPERATURE CONVERSION TABLES. (from Kent.)

IV.—Centigrade to Fahrenheit.

C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C	F.
-40	-40.	26	78.8	92	197.6	158	316.4	224	435.2	290	554	950	1742
-39	-38.2	27	80.6	93	199.4	159	318.2	225	437.	300	572	960	1760
-38	-36.4	28	82.4	94	201.2	160	320.	226	438.8	310	590	970	1778
-37	-34.6	29	84.2	95	203.	161	321.8	227	440.6	320	608	980	1796
-36	-32.8	30	86.	96	204.8	162	323.6	228	442.4	330	626	990	1814
-35	-31.	31	87.8	97	206.6	163	325.4	229	444.2	340	644	1000	1832
-34	-29.2	32	89.6	98	208.4	164	327.2	230	446.	350	662	1010	1850
-33	-27.4	33	91.4	99	210.2	165	329.	231	447.8	360	680	1020	1868
-32	-25.6	34	93.2	100	212.	166	330.8	232	449.6	370	698	1030	1886
-31	-23.8	35	95.	101	213.8	167	332.6	233	451.4	380	716	1040	1904
-30	-22	36	96.8	102	215.6	168	334.4	234	453.2	390	734	1050	1922
-29	-20.2	37	98.6	103	217.4	169	336.2	235	455	400	752	1060	1940
-28	-18.4	38	100.4	104	219.2	170	338.	236	456.8	410	770	1070	1958
-27	-16.6	39	102.2	105	221.	171	339.8	237	458.6	420	788	1080	1976
-26	-14.8	40	104.	106	222.8	172	341.6	238	460.4	430	806	1090	1994
-25	-13.	41	105.8	107	224.6	173	343.4	239	462.2	440	824	1100	2012
-24	-11.2	42	107.6	108	226.4	174	345.2	240	464.	450	842	1110	2030
-23	- 9.4	43	109.4	109	228.2	175	347.	241	465.8	460	860	1120	2048
-22	- 7.6	44	111.2	110	230	176	348.8	242	467.6	470	878	1130	2066
-21	- 5.8	45	113.	111	231.8	177	350.6	243	469.4	480	896	1140	2084
-20	- 4.	46	114.8	112	233.6	178	352.4	244	471.2	490	914	1150	2102
-19	- 2.2	47	116.6	113	235.4	179	354.2	245	473	500	932	1160	2120
-18	- 0.4	48	118.4	114	237.2	180	356.	246	474.8	510	950	1170	2138
-17	+ 1.4	49	120.2	115	239	181	357.8	247	476.6	520	968	1180	2156
-16	3.2	50	122.	116	240.8	182	359.6	248	478.4	530	986	1190	2174
-15	5.	51	123.8	117	242.6	183	361.4	249	480.2	540	1004	1200	2192
-14	6.8	52	125.6	118	244.4	184	363.2	250	482.	550	1022	1210	2210
-13	8.6	53	127.4	119	246.2	185	365.	251	483.8	560	1040	1220	2228
-12	10.4	54	129.2	120	248.	186	366.8	252	485.6	570	1058	1230	2246
-11	12.2	55	131.	121	249.8	187	368.6	253	487.4	580	1076	1240	2264
-10	14.	56	132.8	122	251.6	188	370.4	254	489.2	590	1094	1250	2282
- 9	15.8	57	134.6	123	253.4	189	372.2	255	491.	600	1112	1260	2300
- 8	17.6	58	136.4	124	255.2	190	374.	256	492.8	610	1130	1270	2318
- 7	19.4	59	138.2	125	257.	191	375.8	257	494.6	620	1148	1280	2336
- 6	21.2	60	140.	126	258.8	192	377.6	258	496.4	630	1166	1290	2354
- 5	23.	61	141.8	127	260.6	193	379.4	259	498.2	640	1184	1300	2372
- 4	24.8	62	143.6	128	262.4	194	381.2	260	500.	650	1202	1310	2390
- 3	26.6	63	145.4	129	264.2	195	383.	261	501.8	660	1220	1320	2408
- 2	28.4	64	147.2	130	266.	196	384.8	262	503.6	670	1238	1330	2426
- 1	30.2	65	149.	131	267.8	197	386.6	263	505.4	680	1256	1340	2444
0	32.	66	150.8	132	269.6	198	388.4	264	507.2	690	1274	1350	2462
+ 1	33.8	67	152.6	133	271.4	199	390.2	265	509.	700	1292	1360	2480
2	35.6	68	154.4	134	273.2	200	392.	266	510.8	710	1310	1370	2498
3	37.4	69	156.2	135	275.	201	393.8	267	512.6	720	1328	1380	2516
4	39.2	70	158.	136	276.8	202	395.6	268	514.4	730	1346	1390	2534
5	41.	71	159.8	137	278.6	203	397.4	269	516.2	740	1364	1400	2552
6	42.8	72	161.6	138	280.4	204	399.2	270	518.	750	1382	1410	2570
7	44.6	73	163.4	139	282.2	205	401.	271	519.8	760	1400	1420	2588
8	46.4	74	165.2	140	284.	206	402.8	272	521.6	770	1418	1430	2606
9	48.2	75	167.	141	285.8	207	404.6	273	523.4	780	1436	1440	2624
10	50.	76	168.8	142	287.6	208	406.4	274	525.2	790	1454	1450	2642
11	51.8	77	170.6	143	289.4	209	408.2	275	527.	800	1472	1460	2660
12	53.6	78	172.4	144	291.2	210	410.	276	528.8	810	1490	1470	2678
13	55.4	79	174.2	145	293.	211	411.8	277	530.6	820	1508	1480	2696
14	57.2	80	176.	146	294.8	212	413.6	278	532.4	830	1526	1490	2714
15	59.	81	177.8	147	296.6	213	415.4	279	534.2	840	1544	1500	2732
16	60.8	82	179.6	148	298.4	214	417.2	280	536.	850	1562	1510	2750
17	62.6	83	181.4	149	300.2	215	419.	281	537.8	860	1580	1520	2768
18	64.4	84	183.2	150	302.	216	420.8	282	539.6	870	1598	1530	2786
19	66.2	85	185.	151	303.8	217	422.6	283	541.4	880	1616	1540	2804
20	68.	86	186.8	152	305.6	218	424.4	284	543.2	890	1634	1550	2822
21	69.8	87	188.6	153	307.4	219	426.2	285	545.	900	1652	1600	2912
22	71.6	88	190.4	154	309.2	220	428.	286	546.8	910	1670	1650	3002
23	73.4	89	192.2	155	311.	221	429.8	287	548.6	920	1688	1700	3092
24	75.2	90	194.	156	312.8	222	431.6	288	550.4	930	1706	1750	3182
25	77.	91	195.8	157	314.6	223	433.4	289	552.2	940	1724	1800	3272

V.—Fahrenheit to Centigrade.

F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.
-40	-40.	26	- 3.3	92	33.3	158	70.	224	106.7	290	143.3	360	182.2
-39	-39.4	27	- 2.8	93	33.9	159	70.6	225	107.2	291	143.9	370	187.8
-38	-38.9	28	- 2.2	94	34.4	160	71.1	226	107.8	292	144.4	380	193.3
-37	-38.3	29	- 1.7	95	35.	161	71.7	227	108.3	293	145.	390	198.9
-36	-37.8	30	- 1.1	96	35.6	162	72.2	228	108.9	294	145.6	400	204.4
-35	-37.2	31	- 0.6	97	36.1	163	72.8	229	109.4	295	146.1	410	210.
-34	-36.7	32	0.	98	36.7	164	73.3	230	110.	296	146.7	420	215.6
-33	-36.1	33	+ 0.6	99	37.2	165	73.9	231	110.6	297	147.2	430	221.1
-32	-35.6	34	1.1	100	37.8	166	74.4	232	111.1	298	147.8	440	226.7
-31	-35.	35	1.7	101	38.3	167	75.	233	111.7	299	148.3	450	232.2
-30	-34.4	36	2.2	102	38.9	168	75.6	234	112.2	300	148.9	460	237.8
-29	-33.9	37	2.8	103	39.4	169	76.1	235	112.8	301	149.4	470	243.3
-28	-33.3	38	3.3	104	40.	170	76.7	236	113.3	302	150.	480	248.9
-27	-32.8	39	3.9	105	40.6	171	77.2	237	113.9	303	150.6	490	254.4
-26	-32.2	40	4.4	106	41.1	172	77.8	238	114.4	304	151.1	500	260.
-25	-31.7	41	5.	107	41.7	173	78.3	239	115.	305	151.7	510	265.6
-24	-31.1	42	5.6	108	42.2	174	78.9	240	115.6	306	152.2	520	271.1
-23	-30.6	43	6.1	109	42.8	175	79.4	241	116.1	307	152.8	530	276.7
-22	-30.	44	6.7	110	43.3	176	80.	242	116.7	308	153.3	540	282.2
-21	-29.4	45	7.2	111	43.9	177	80.6	243	117.2	309	153.9	550	287.8
-20	-28.9	46	7.8	112	44.4	178	81.1	244	117.8	310	154.4	560	293.3
-19	-28.3	47	8.3	113	45.	179	81.7	245	118.3	311	155.	570	298.9
-18	-27.8	48	8.9	114	45.6	180	82.2	246	118.9	312	155.6	580	304.4
-17	-27.2	49	9.4	115	46.1	181	82.8	247	119.4	313	156.1	590	310.
-16	-26.7	50	10.	116	46.7	182	83.3	248	120.	314	156.7	600	315.6
-15	-26.1	51	10.6	117	47.2	183	83.9	249	120.6	315	157.2	610	321.1
-14	-25.6	52	11.1	118	47.8	184	84.4	250	121.1	316	157.8	620	326.7
-13	-25.	53	11.7	119	48.3	185	85.	251	121.7	317	158.3	630	332.2
-12	-24.4	54	12.2	120	48.9	186	85.6	252	122.2	318	158.9	640	337.8
-11	-23.9	55	12.8	121	49.4	187	86.1	253	122.8	319	159.4	650	343.3
-10	-23.3	56	13.3	122	50.	188	86.7	254	123.3	320	160.	660	348.9
- 9	-22.8	57	13.9	123	50.6	189	87.2	255	123.9	321	160.6	670	354.4
- 8	-22.2	58	14.4	124	51.1	190	87.8	256	124.4	322	161.1	680	360.
- 7	-21.7	59	15.	125	51.7	191	88.3	257	125.	323	161.7	690	365.6
- 6	-21.1	60	15.6	126	52.2	192	88.9	258	125.6	324	162.2	700	371.1
- 5	-20.6	61	16.1	127	52.8	193	89.4	259	126.1	325	162.8	710	376.7
- 4	-20.	62	16.7	128	53.3	194	90.	260	126.7	326	163.3	720	382.2
- 3	-19.4	63	17.2	129	53.9	195	90.6	261	127.2	327	163.9	730	387.8
- 2	-18.9	64	17.8	130	54.4	196	91.1	262	127.8	328	164.4	740	393.3
- 1	-18.3	65	18.3	131	55.	197	91.7	263	128.3	329	165.	750	398.9
0	-17.8	66	18.9	132	55.6	198	92.2	264	128.9	330	165.6	760	404.4
+ 1	-17.2	67	19.4	133	56.1	199	92.8	265	129.4	331	166.1	770	410.
2	-16.7	68	20.	134	56.7	200	93.3	266	130.	332	166.7	780	415.6
3	-16.1	69	20.6	135	57.2	201	93.9	267	130.6	333	167.2	790	421.1
4	-15.6	70	21.1	136	57.8	202	94.4	268	131.1	334	167.8	800	426.7
5	-15.	71	21.7	137	58.3	203	95.	269	131.7	335	168.3	810	432.2
6	-14.4	72	22.2	138	58.9	204	95.6	270	132.2	336	168.9	820	437.8
7	-13.9	73	22.8	139	59.4	205	96.1	271	132.8	337	169.4	830	443.3
8	-13.3	74	23.3	140	60.	206	96.7	272	133.3	338	170.	840	448.9
9	-12.8	75	23.9	141	60.6	207	97.2	273	133.9	339	170.6	850	454.4
10	-12.2	76	24.4	142	61.1	208	97.8	274	134.4	340	171.1	860	460.
11	-11.7	77	25.	143	61.7	209	98.3	275	135.	341	171.7	870	465.6
12	-11.1	78	25.6	144	62.2	210	98.9	276	135.6	342	172.2	880	471.1
13	-10.6	79	26.1	145	62.8	211	99.4	277	136.1	343	172.8	890	476.7
14	-10.	80	26.7	146	63.3	212	100.	278	136.7	344	173.3	900	482.2
15	- 9.4	81	27.2	147	63.9	213	100.6	279	137.2	345	173.9	910	487.8
16	- 8.9	82	27.8	148	64.4	214	101.1	280	137.8	346	174.4	920	493.3
17	- 8.3	83	28.3	149	65.	215	101.7	281	138.3	347	175.	930	498.9
18	- 7.8	84	28.9	150	65.6	216	102.2	282	138.9	348	175.6	940	504.4
19	- 7.2	85	29.4	151	66.1	217	102.8	283	139.4	349	176.1	950	510.
20	- 6.7	86	30.	152	66.7	218	103.3	284	140.	350	176.7	960	515.6
21	- 6.1	87	30.6	153	67.2	219	103.9	285	140.6	351	177.2	970	521.1
22	- 5.6	88	31.1	154	67.8	220	104.4	286	141.1	352	177.8	980	526.7
23	- 5.	89	31.7	155	68.3	221	105.	287	141.7	353	178.3	990	532.2
24	- 4.4	90	32.2	156	68.9	222	105.6	288	142.2	354	178.9	1000	537.8
25	- 3.9	91	32.8	157	69.4	223	106.1	289	142.8	355	179.4	1010	543.3

kilometres to be capable of supporting vegetation, the amount of power so converted from the radiating energy of the sun would also reach an imposing figure. For many thousands of years this vegetable growth with its incident mouldering and decaying processes, has been in operation as a radiating-energy accumulator, gathering into the earth's crust stores of energy in the form of peat, lignite, coal, etc.

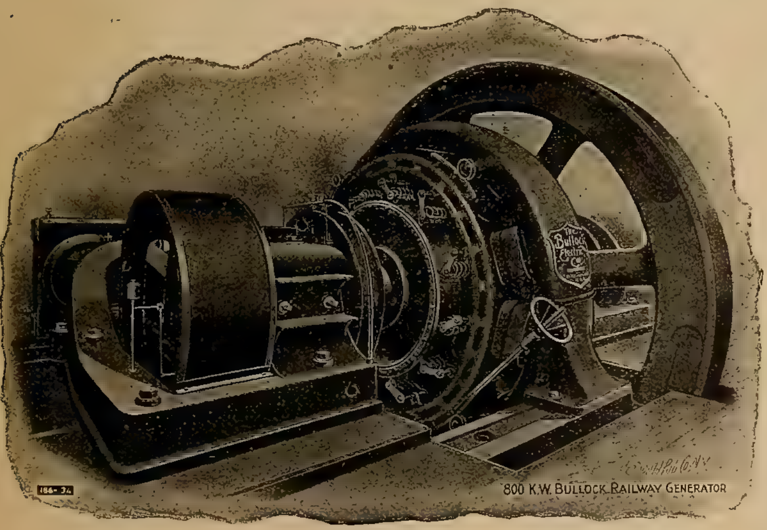
Up to the present time we have consumed principally the last-named stores, and that in no economical manner, using the most of the best, because considerations of transportation required the greatest possible storage of energy per unit of weight. The turf and coal beds of lower calorific value have hardly been noticed, and large industrial centers have been developed upon richer coal basins. Only within the last few decades have the favorable opportunities offered by nature to draw upon cheap and available power been utilized, and these have been mainly water powers. A point here or there, situated near the great thoroughfares of commerce, has already admitted of a better exploitation of a water power, but on the whole, notwithstanding the best intentions of an active spirit of enterprise, there has been a lack of effective work.

Industrial

In responding to advertisements in this publication kindly mention "The Journal of Electricity, Power and Gas."

BULLOCK ENGINE TYPE GENERATORS.

PROMINENT as marking the entry of a new concern into the field occupied by the comparatively few builders of direct connected direct current generators is the new machine recently brought out by the Bullock Electric Manufacturing Co., of Cincinnati, O. Among the more important features embodied in this new machine may be mentioned the scheme for oscillating the brush holder mechanism in a direction parallel with the shaft. The movement is very slow and results in constantly changing the line of travel over the commutator face and thus removes all tendency to cut or groove the latter. The action is the same as secured by the end play of an armature in a belted generator or that produced by the electro magnetic device used at the end of shaft on rotary transformers, and which is recognized by engineers as a means of greatly prolonging the life of the commutator.


800 K.W. BULLOCK RAILWAY GENERATOR

The pole pieces and coils may be removed without disturbing the yoke or armature, and with two of them removed, it is possible to remove one or more armature coils should repairs be necessary.

The armature coils are made of continuous bars of copper without joints between the commutator connections which materially adds to the life of the machine. These coils are all thoroughly insulated, pressed and baked before being placed on the core, no additional core insulation being necessary. All armatures are thoroughly ventilated by slots perpendicular to the shaft through which the air rushes when the machine is in operation. A liberal rating permits of constant operation at full load with low temperature rise. One of the 800 K. W. machines has been sold to the Oakland Rapid Transit Company, of Oakland, Cal., and is shown in the engraving. This machine operates at a speed of 80 R. P. M., and at this speed develops 550 volts at no load.

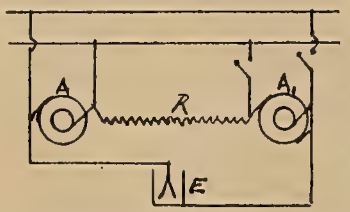
It is over-compounded for a rise of 50 volts at full load, making the full load voltage 600.

Obituary

CAPT. J. F. LUTTRELL died at Marysville, Cal., on November 4th, from pneumonia, after a very brief illness. At the time of his death he was general manager for the Yuba Power Company, with headquarters at Marysville, and though not generally known in electrical or engineering circles, those who were so fortunate as to have made his acquaintance will always cherish his memory as being that of one who was possessed of all that goes to make man loved and esteemed by his fellow men.

AYRTON'S ELECTROSTATIC SYNCHRONIZER.

SYNCHRONIZING transformers are unnecessary when the Ayrton electrostatic synchronizer is used. The system is very simple. R is a resistance, such as a thin line made by a lead pencil on a piece of slate; E is any dead-beat electrostatic voltmeter, such as a gold leaf electroscope which may be made with leaves even eighteen inches long, so as to be seen all over the station; and A and A_1 are the two alternators to be thrown in parallel on the 'bus bars shown. The moment for switching-in is when the leaves stay closed or are together for some appreciable time.



Prof. Ayrton claims that this method is more dead-beat than a lamp, that it is cheaper than the ordinary methods, that it may be of any size, that it requires neither calibration or scale, and that it is perfectly and absolutely safe.

PLOTTING MAGNETIC FIELDS.*

BY W. W. GRIFFITH.

THERE are three different ways of experimentally plotting the lines of force of a magnetic field. One is Faraday's method of iron filings; another consists of drawing elements of the curves from the orientation of a small magnetic needle passed along then; a third consists of observing the motion of a floating needle. These three methods give different results and for obvious reasons. A small particle of iron is influenced by its neighboring particles as well as by the magnet. Being a magnet by induction, its magnetism decreases rapidly as the distance increases, and, therefore, the earth's field has less disturbing effect on the filing-marked lines than on the lines plotted by means of a permanently magnetized needle. The third method is most closely in accord with the definition of a line of force as the line along which an elementary pole would move; but that pole is supposed to be free from inertia, which would otherwise tend to make the needle move on in a straight line.

---

*Abstract from *Terrestrial Magnetism*, September, 1899.

INDEX TO ADVERTISEMENTS.

Abner Doble Company, Fremont and Howard streets, San Francisco.
Iron, Steel, Mining and Milling Supplies, Rock-Drills, Air Compressors, Crocker-Wheeler Dynamos and Motors, Cutler-Hammer Electrical Apparatus, the Doble Ellipsoidal Water Wheels........See page viii

Babcock & Wilcox Co., 29 Cortlandt street, New York, and Pacific Coast office, 32 First street, San Francisco.
Babcock & Wilcox Water Tube Steam Boilers........See page iii

Bates, Frank H., 933 Market street, San Francisco.
Chemical and Gas Engineer........See page iii

Benjamin, Edward H., 331 Pine street, San Francisco.
Mining Engineer........See page iii

Brooks-Follis Electric Corporation, 523–525 Mission street, San Francisco.
Pacific Coast Agents for Sprague Electric Co., Stirling Varnish Co, Mica Insulator Co., Eugene Munsell & Co., Pennsylvania Electric Co. and Fostoria Incandescent Lamp Co., Electrical Supplies of every description, Contracting........See page ii

California Electrical Works, 409 Market street, San Francisco.
Pacific Coast Agents for W. R. Brixey, Western Electric Co, Buckeye Electric Co., Bryant Electric Co, Warren-Medberry Co., Whitney Electrical Instrument Co., Edison Manufacturing Co., Rushmore Dynamo Works, Interior Conduit and Insulation Co., Eddy Electric Manufacturing Co., Helios Electric Co., Diamond Electric Co., H. W. Johns Manufacturing Co., Medical Cabinets, Switchboards, Telephones, Armature and Transformer Building and Rewinding, Model Making, Contracting, General Electrical Repairs, Electrical supplies of every description..See page iv

Cobb & Hesselmeyer, 421 Market street, San Francisco.
Consulting, Supervising and Constructing Mechanical and Hydraulic Engineers........See page iii

Cole, John R., 83 Flood Building, San Francisco.
Pacific Coast Sales Agent Grimshaw Wires, Cutter C-S Flush Switches and I-T-E Circuit Breakers, Paiste's Sockets, Rosettes, Switches, K. W. Rosettes, and Porcelain Goods, Circular Loom Flexible Conduit, Electroduct, Akron Knobs, Cleats, Bushings and Porcelain Goods, Reisinger's "Electra" Carbons, Pringle's Plug Receptacles........See page ix

Electrical Engineering Co., 509–511 Howard street, San Francisco.
Direct Current Dynamos and Motors, Electric Elevators for Passenger, Freight and Dumb-waiter service, Mining Hoists, Direct Current Transmissions, Builders' Electric Donkeys, General Rewinding and Repairs, Tool, Lathe and Machine Work........See page ix

General Electric Company, Claus Spreckels Building, San Francisco.
Edison Lamps, Sockets, Switches, Fuses, etc., Direct-current, Single-phase, Monocyclic and Polyphase Dynamos and Motors, Brush Arc Lighting System, Transformers, Synchronous and Induction Motors, Marine Installations, Power Transmissions........See page i

Heald's School of Engineering, 24 Post street, San Francisco.
Business College and School of Mining and Electrical Engineering and Assaying........See page v

Hunt, A. M., 331 Pine street, San Francisco.
Consulting, Mechanical and Hydraulic Engineer........See page iii

Jackson, Byron, 625 Sixth street, San Francisco.
Centrifugal Pumps, Oil Motors, Steam Engines, Shop Work....See page x

Knight & Co., Sutter Creek, Cal.
The Knight Water Wheel, Hydraulic and Cornish Pumps, Mining Cars and Cages, Horizontal and Vertical Engines, Automatic Water Power Attachments, Hoists, Quartz Mills, Sheet-iron Pipe, Water and Ore Buckets, General Foundry and Machine Shops........See page v

Knowles, C. S., 7 Arch street, Boston, Mass.
General Sales Agent Imperial Porcelain High Potential Insulators, Electric Light, Power and Transmission Supplies of every description..See page iv

Locke, Fred M., Victor, N. Y.
Locke Glass and Porcelain Insulators, Steel Pins, Break Arms, Side Brackets, Ridge Irons and Line Materials for all services....See page vii

Meredith, Wynn, 319 Pine street, San Francisco.
Consulting, Supervising and Constructing Electrical Engineer..See page iii

Moore & Co., Chas. C., 32 First street, San Francisco.
Pacific Coast Agents for Babcock & Wilcox Boilers, McIntosh & Seymour Engines, Hamilton-Corliss Engines, N. Y. Safety Automatic Engines, Green's Economizers, Wheeler Condensers, Barnard-Wheeler Cooling Towers, Hoppes' Live Steam Purifiers, Goubert Feed Water Heaters, Stratton Steam Separators, Snow Steam Pumps, Quimby Screw Pumps, Edmiston Feed Water Filters, Geipel Steam Traps, Spencer Damper Regulators, Hyatt Roller Bearings, Chapman Valves, Holly Gravity Feedwater Return System........See page iii

Martin, John, 300 California street, San Francisco.
Pacific Coast Agent Locke Insulators and Line Materials, Pittsburg Reduction Co.'s Aluminum Wires for Electrical Circuits, Stanley Electric Manufacturing Co.'s "S. K. C." system for electrical transmission and distribution........See pages vi, vii, viii

New York Insulated Wire Co., The, 15–19 Cortlandt street, New York; John R. Cole, Sales Agent, 83 Flood Building, San Francisco.
Sole Manufacturers of Grimshaw, Raven and Competition Rubber covered Wires, Tapes and Splicing Compounds, Large Cables and Leaded Cables of any voltage........See page iv

Oakland Iron Works, Second and Jefferson streets, Oakland, Cal.
Manufacturers of Tutthill Patent Tangential Water Wheels, Marine Engines and Boilers, Ice and Refrigerating Machines, General Foundries and Repair Shops........See page iii

Okonite Co., (Ltd.), The, 253 Broadway, New York.
Sole Manufacturers of Okonite Wires, Cables and Tape, Manson Tape, Candee Weatherproof Wires........See page i

Pacific Incandescent Lamp Co., 933 Market street, San Francisco.
Manufacturers and Renewers of Incandescent Lamps of all voltages and in all candle powers........See page iii

Paraffine Paint Co., 116 Battery street, San Francisco.
Manufacturers of P. & B. Armature and Field Coil Varnish, Electrical Compound, Insulating Tape, Roofing, Building Paper and Paint..See page vii

Pelton Water Wheel Co., 127 Main street, San Francisco.
Manufacturers of Pelton Tangential Water Wheels........See page vii

Pittsburg Reduction Co., Pittsburg, Pa.; John Martin, Agent, 300 California street, San Francisco.
Manufacturers of Aluminum in Ingots Plates, Bars, Sheets, Tubes, Wire and Castings Specialty: Aluminum Wire, Rods and Bars expressly for Electrical conductors........See page vi

Ridley, A. E. Brooke, 597–599a Parrott Building, San Francisco.
Electrical Engineer and Contractor; Pacific Coast Agent Electric Storage Battery Company, Siemens & Halske Electric Company of America, Manhattan Arc Lamps, Apparatus and Supplies........See page iv

Sprout, Sidney, 106 Crocker Building, San Francisco.
Consulting, Supervising and Constructing Electrical Engineer..See page iii

Standard Underground Cable Co., Pittsburg, Pa.; Chas. F. Sloane, Pacific Coast Agent, room 1, second floor, Mills Building, San Francisco.
Fibre Paper and Rubber Cables, Telephone, Electric Light and Power Cables, High-grade Rubber and Weatherproof Wires........See page i

Stanley Electric Manufacturing Company, Pittsfield, Mass.; John Martin, Agent, 300 California street, San Francisco.
Manufacturers of the "S. K. C" System for Long-distance Transmission, Central-station Distribution, Mill and Factory Equipment, Generators, Induction and Synchronous Motors, Incandescent and Arc Lighting, Transformers, Lightning Arresters, Switchboards........See page xii

Union Lumber Co., 28 Crocker Building, San Francisco.
General Dealers in Lumber. Specialty: Redwood Poles for Telegraph, Telephone, Electric-light, Power and Transmission Plants.....See page v

Van der Naillen School of Engineering, 933 Market street, San Francisco.
School of Practical Electrical, Civil, Mining and Mechanical Engineering, and of Surveying, Drawing Architecture and Assaying........See page v

Wagner Electric Manufacturing Co., St. Louis, Mo.; Pacific Coast office, 120 Sutter Street, San Francisco.
Alternating-current Transformers and Motors in all sizes....See page viii

Westinghouse, Church, Kerr & Co.
Steam and Gas Engine Engineers........See page vi

Westinghouse Electric and Manufacturing Co., Pittsburg, Pa.; Pacific Coast office, Mills Building, San Francisco.
Alternating and Direct Current Electrical Apparatus of every description for every character of service........See page vi

Westinghouse Machine Co., Pittsburg, Pa.
Builders of Westinghouse Gas and Steam Engines........See page vi

Weston Electrical Instrument Company, 114–120 Williams street, Newark, N. J.
Sole Manufacturers of Weston Standard Portable and Station Direct-reading Voltmeters, Millivoltmeters, Voltameters, Ammeters, Milliammeters, Ground Detectors, Circuit Testers, Galvanometers and Ohmmeters........See page i

INDEX TO VOLUME VIII.

Authors

PAGE

Babcock, Allen H. 81
Bates, Frank H. 24, 42, 75, 96, 114, 132
Bean, Harry J., A. B., E. E. 61
Borchers, Dr. W 136
Bowie, Aug. J., Jr. 105
Brooks, Prof. Orion 83
Cory, Prof. C. L. 33
Doble, W. A., M. E. 85
Emmet, W. L. R. 109
Griffith, W. W. 137
Hicks, Lewis A., C. E. 3
Hutton, C. Wm. 15
Jones, Willis H. 100
Markill, R. F. 108
Martin, John 11
Perrine, F. A. C., D. Sc. 41
Robb, W. L. 89
Van der Naillen, Albert, Sr. 128
Van Norden, R. W. 14
Scott, Chas. F. 121

Distribution

*Electrically-Driven Centrifugal Pumps, by Lewis A. Hicks, C. E. 3
*Induction Motors, by R. F. Markill 108
*Localizing Faults in Concentric Cables 23
Motor Generators vs. Gravity Batteries 101
"Pumping" of Rotary Converters 89
*Rectification of Alternating Currents 93
*Regulating Secondary Voltages 118
Rotaries in the Hartford Plant, by W. L. Robb 89
*Service Charges at a Glance 92
Single-phase, Self-starting Motors 55
The Determination of a Fair Return for Current Supply, by C. Wm. Hutton 15
*The Kasten Slow-Speed Motor 32
The Sprague-Lundell Fan Motors 32

Electro-Insurance

Destruction of the Blue Lakes Power Plant 107
†The Blue Lakes Fire 113

Gas

*Industrial Gas, by Frank H. Bates 24, 42, 75, 96, 114, 132
†On the Inefficiency of Acetylene 21
The Green-Howard Gas Controversy 71

Generation

*Bullock Engine Type Generators 137
Electrical Costs in San Francisco 78
Load Factors and Generation Costs 91
†Measuring Dynamo Efficiencies 96
*Seven 2000-Horsepower Transformers 103
†Siemens & Halske Alternating Machinery 22
*The Regulation of Alternating-Current Generators, by Prof. C. L. Cory 33

Historical

*An Early Jablochkoff Alternator, by Prof. Orion Brooks 83

Hydraulics

†Impound the State's Flood Waters 95
*Tangential Water Wheels, by W. A. Doble, M. E. 85

Illumination

Electric Lighting versus Gas, by John Martin 11
Electric Railway Train Lighting 19
†It Means Business 20
Measurement of Light 119
†Municipal Ownership There and Here 94
Refill Your Burned-Out Lamps 32
†The Edison Three-Wire Patent 22

Literature

PAGE

"Electrical and Mechanical Vest-Pocket Manual," by Sidney Sprout 32
Farming by Electric Power 111
†Prof. Forbes Makes a Correction 23
Machinists' and Engineers' Pocket Manual 84
The Steam Engine Indicator 104

Miscellany

*Ayrton's Electrostatic Synchronizer 137
†Messrs. Keeley, Howard & Co., Frauds 74
Plotting Magnetic Fields, by W. W. Griffith 137
Purity of Aluminum 93
†The Policy of the JOURNAL 20
†The Story of the Three Eggs, Improved 22
The Sun as a Source of Energy, by Dr. W. Borchers 136

Obituary

Brooks, Herbert H. 60
Luttrell, Capt. J. F. 137
Neisser, Aug. H. 60

Operation

*An Induction Factor Meter, by Allen H. Babcock 81
*Breaking Heavy High-Tension Circuits, by W. L. R. Emmet 109
*High-Tension Switches at Bakersfield 110
Insulating and Baking Methods 120
*Measuring Insulation of Alternating Circuits 109
†Philosophy of Synchronizing Alternators 130
*Testing Live Circuits 80
The Rotative Direction of Polyphase Motors 40
*Three-Phase Synchronizing Methods 102
*Transformer Ratios Easily Determined 90

Personal

23, 25, 111, 129

Steam

Steam Engineering Efficiency 129

Telegraphy

*The Principle of Wireless Telegraphy, by Willis H. Jones 100
Wireless Telegraphy as It Is 101

Trade Literature

84, 104, 120

Transmission

A 25,000-volt Direct-Current Transmission 119
*Aluminum for Electrical Conductors 27
Convention of the Transmission Association 31
*Current in Two and Three Phase Lines 90
†High Voltage Transmission Limitations 131
Hints on Long-Distance Transmission, by R. W. Van Norden 14
Insulators on the Snoqualmie Line 82
Long Spans of Overhead Wires 19
Niagara Falls Prints Newspapers 104
Official Report of the Transactions of the Third Annual Transmission Convention 49, 63
*Polyphase Transmission, by Chas. F. Scott 121
*Tests and Calculations for a Forty-Mile Aluminum Wire Transmission Line, by F. A. C. Perrine, D. Sc. 41
*The Disposition of Three-Phase Transmission Lines, by Aug. J. Bowie, Jr. 105
†The Electric Transmission Convention 46
The Locke Patent Sustained 104
†Transmission as Viewed by a Coal Merchant 74

Transportation

*Burgdorf-Thun-Bahn Polyphase Railway, by A. van der Naillen, Sr. 128
†Polyphase Electric Traction 72
†Polyphase Traction Again 112
*A Typical Small Street-Railway Plant, by Harry J. Bean, A. B., E. E. 61

* Illustrated. † Editorial.

1899

Polyphase Transmission

The Journal of ELECTRICITY POWER AND GAS

DEVOTED TO THE CONVERSION, TRANSMISSION AND DISTRIBUTION OF ENERGY.

VOL. VIII.—No. 6. SAN FRANCISCO, CAL., DECEMBER, 1899. {YEARLY SUBSCRIPTION, $1.00 {SINGLE COPIES, - - 10 CENTS

WESTON ELECTRICAL INSTRUMENT CO.,
114-120 William St.,
NEWARK - - - N. J., U. S. A.

Weston Standard Portable Direct Reading
VOLTMETERS, MILLIVOLTMETERS,
VOLTAMMETERS, AMMETERS,
MILLIAMMETERS,
GROUND DETECTORS and CIRCUIT TESTERS, OHMMETERS,
PORTABLE GALVANOMETERS.

Our Portable Instruments are Recognized as the STANDARD the world over. The SEMI-PORTABLE LABORATORY STANDARDS are still better. Our STATION VOLTMETERS and AMMETERS are unsurpassed in point of extreme accuracy and lowest consumption of energy.

1889 PARIS EXPOSITION MEDAL FOR RUBBER INSULATION

OKONITE TRADE MARK.

1893 WORLD'S FAIR MEDAL FOR RUBBER INSULATION

SOLE MANUFACTURERS OF

OKONITE TAPE : : MANSON TAPE

CANDEE WEATHER=PROOF WIRES

THE OKONITE COMPANY, Ltd.,

Willard H. Candee } Managers
H. Durant Cheever }
Geo. T. Manson, General Superintendent
W. H. Hodgins, Secretary

253 Broadway,
NEW YORK

NEW YORK PHILADELPHIA PITTSBURG CHICAGO SAN FRANCISCO

"STANDARD" TRADE MARK

STANDARD FIBER PAPER RUBBER CABLES UNDERGROUND TELEPHONE ELECTRIC LIGHT AND POWER CABLES CABLE HIGH GRADE RUBBER AND WEATHER PROOF WIRES CO.

Inquire about the work we have done and the thousands of miles of Feeder Cables (aerial and underground) we have furnished and installed for electric railway and other companies. The replies will interest you.

Factories at Perth Amboy, N. J., Pittsburg, Pa., and Oakland, Cal.

Pacific Coast Sales Agent, CHAS. F. SLOANE. Room 1, Second Floor, MILLS BUILDING, San Francisco

General Electric Company

Schenectady, N. Y.

Claus Spreckels Building,
SAN FRANCISCO, CAL.

Worcester Building, PORTLAND, OR.

. . . . ALL THE . . . .

Three=Phase Generators

Air Blast Transformers

Short Gap Lightning Arresters

—used in the—

GREAT POWER TRANSMISSIONS

of CALIFORNIA, COLORADO, UTAH and OREGON are

GENERAL ELECTRIC.

Manufacturers of the STANDARD ELECTRICAL APPARATUS of the World

Have you mislaid our catalogues?

Is the discount sheet missing?

"MAMMA"

From a painting by Mrs. Grace Hudson, in San Francisco Press Club Collection.

If you are in the market for

Incandescent Lamps Lighting Supplies

Power Motors Fan Motors Telephones

Sterling Varnish Mica and Micanite

or anything in the ELECTRICAL LINE, we are prepared to supply you from stock.

BROOKS-FOLLIS ELECTRIC CORPORATION

523-525 MISSION STREET,

Telephone MAIN 861

SAN FRANCISCO, CAL.

"Haven't you forgotten something, sir?"

Did you ever hear of the absent-minded man who, having gotten his "goods" over the counter, would have gone off without paying had he not been queried as above?

Or, did you ever know of the thoughtless person who always reads his JOURNAL from cover to cover and who never thinks to send in the price of his subscription?

Do YOU know him?

N. B.—It takes money to make the mare, the automobile, and the JOURNAL go.

DAILY TELEPHONE ITEMS

particularly appeals to construction and supply houses
Subscription price, $60.00 per annum

The weekly issue of DAILY TELEPHONE ITEMS

circulates among the small telephone companies at
$5.00 per annum

Published by FRANK A. BURRELLE, 32 Park Row, New York City

The S. K. C. SYSTEM

A COMPLETE SYSTEM FOR

Long Distance Transmission,

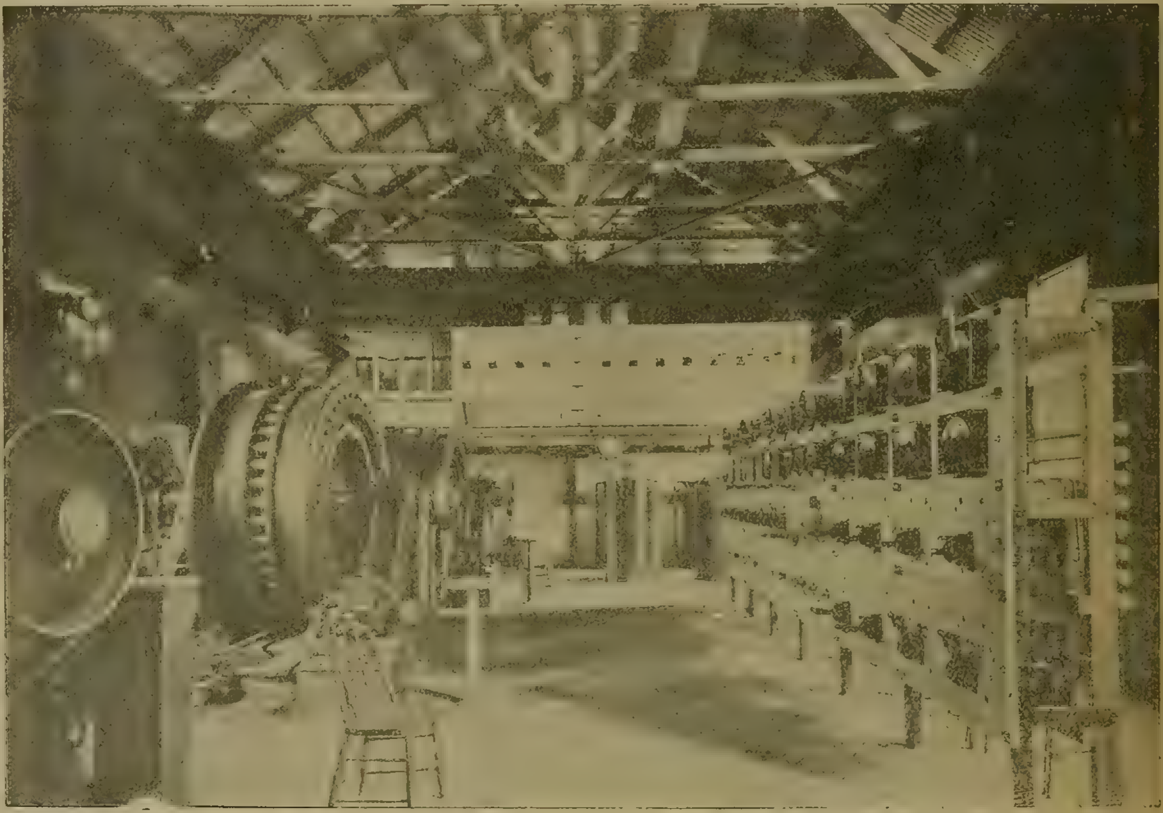
Central Station Distribution,

Mill and Factory Equipment.

GENERATORS WILL BE WOUND AND GUARANTEED FOR ANY E. M. F. UP TO 12,000 VOLTS.

INDUCTION AND SYNCHRONOUS MOTORS, INCANDESCENT LIGHTING, ARC LIGHTING AND POWER TRANSFORMERS HIGH GRADE SWITCHBOARDS.

Correspondence Solicited.



GENERATING STATION, YUBA POWER COMPANY.

Alternating Current Generators. ✲ Belted, Direct-Connected Engine Type. ✲ Single-Phase Two-Phase Three-Phase.

Stanley Electric Manufacturing Co.,

PITTSFIELD, MASS., U. S. A.

JNO. MARTIN, Pacific Coast Agent,

300 CALIFORNIA STREET, San Francisco, Cal.